CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 73 JANUARY 1987 NUMBER 1

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Monterey, CA 93940

CALIFORNIA FISH AND GAME

VOLUME 73 JANUARY 1987 NUMBER 1

Published Quarterly by

STATE OF CALIFORNIA

THE RESOURCES AGENCY

DEPARTMENT OF FISH AND GAME

—LDA—

CONTENTS

Calif. Fish and Game 73(1): 4–20 1987

AGE AND GROWTH OF MALE DUNGENESS CRABS, *CANCER MAGISTER*, IN NORTHERN CALIFORNIA [1]

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Age and growth of male Dungeness crabs, *Cancer magister,* was determined from studies conducted during the period 1972 to 1977. Annual ocean surveys, with concurrent trapping and trawling at selected stations, yielded width-frequency data, in time series, for specific year classes. Recoveries of crabs, tagged at known age, revealed size at age. Observations of molting crabs and single molt tag returns provided molt increment information used to calculate instar sizes. Interpretation of width-frequency data for an unusually abundant 1972 year class was facilitated by the precedence of very weak year classes which helped mitigate cohort overlap. Age (size) group parameters from width-frequency data were generated by a computer programmed separation procedure. Mean sizes of the 1972 year class for ages 0.9, 1.9, 2.9, 3.9 and 4.9 years were 24.7, 93.8, 150.7, 176.1 and 188.6 mm, respectively. Corresponding calculated widths were 26.6, 100.2, 150.7, 177.9 and 206.5 mm. Mean sizes for recaptured, tagged, 1972 year class crabs were 108.0, 151.7 and 167.7 mm for ages 1.6, 2.9 to 3.3 and 4.0 to 4.3. The percentage of northern California Dungeness crabs which attain the legal size of 159 mm at 3 years is variable; however, with minor exception, they are fully recruited at age 4.

INTRODUCTION

Age and growth studies on Dungeness crabs, *Cancer magister,* have been conducted in British Columbia (MacKay and Weymouth 1935, Butler 1961), Washington (Cleaver 1949), California (Poole 1967, Collier 1983). Width frequency analysis, tagged crab returns, and observations of molting crabs were used in these earlier studies for growth determination. My study documents the age and growth of male Dungeness crabs in northern California, with emphasis on the 1972 year class, by applying these methods to an isolated year class, in time series, over several years.

MATERIALS AND METHODS

Dungeness crabs were captured in ocean waters by trawl and trap from California Department of Fish and Game vessels N. B. SCOFIELD and BLUEFIN. Trawls were made with a 41-ft. (12.5-m) head rope, Gulf shrimp trawl with 1⅛ in. (2.9-cm) stretch mesh and a ½-in. (1.3-cm) cod-end liner. Crab traps were 40-in. (1.0-m) commercial type with no escape ports. From 1972 to 1975, daytime trawling was conducted during October and November along transects (Figure 1) at 5-fm (9.1-m) intervals from 10 to 90 fm (18 to 165 m).

Trawls were 15 min. in duration over a ½-nautical mile (0.8-km) distance. Traps, baited with market squid, *Loligo opalescens,* and rockfish, *Sebastes* spp., carcasses, were set immediately adjacent to each trawl station out to 50 fm (91.4 m) and allowed to fish overnight. Collected crabs were sexed and measured to the nearest millimeter carapace width (CW), just anterior to the 10th anterolateral spine.

[1] Accepted for publication August 1986.

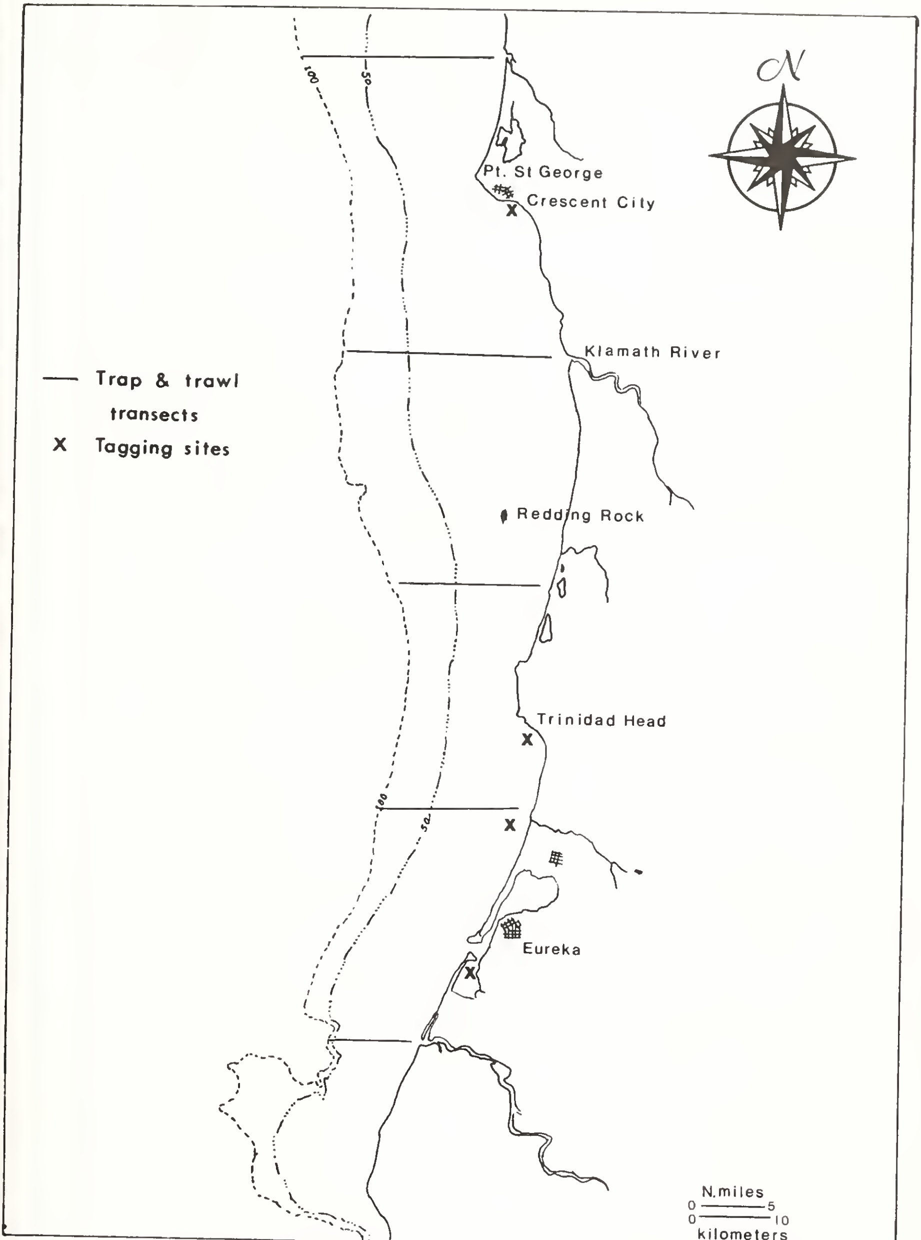

FIGURE 1. Northern California Dungeness crab trawl and trap survey sites from 1972 to 1977.

In south Humboldt Bay, periodic monthly trawling in daylight hours was conducted during 1972 and 1973 (Figure 2). A Gulf shrimp try-net with a 16-ft. (4.9-m) head rope, 1⅛-in. (2.9-cm) stretch mesh, and ½-in. (1.3-cm) liner in the cod end was used.

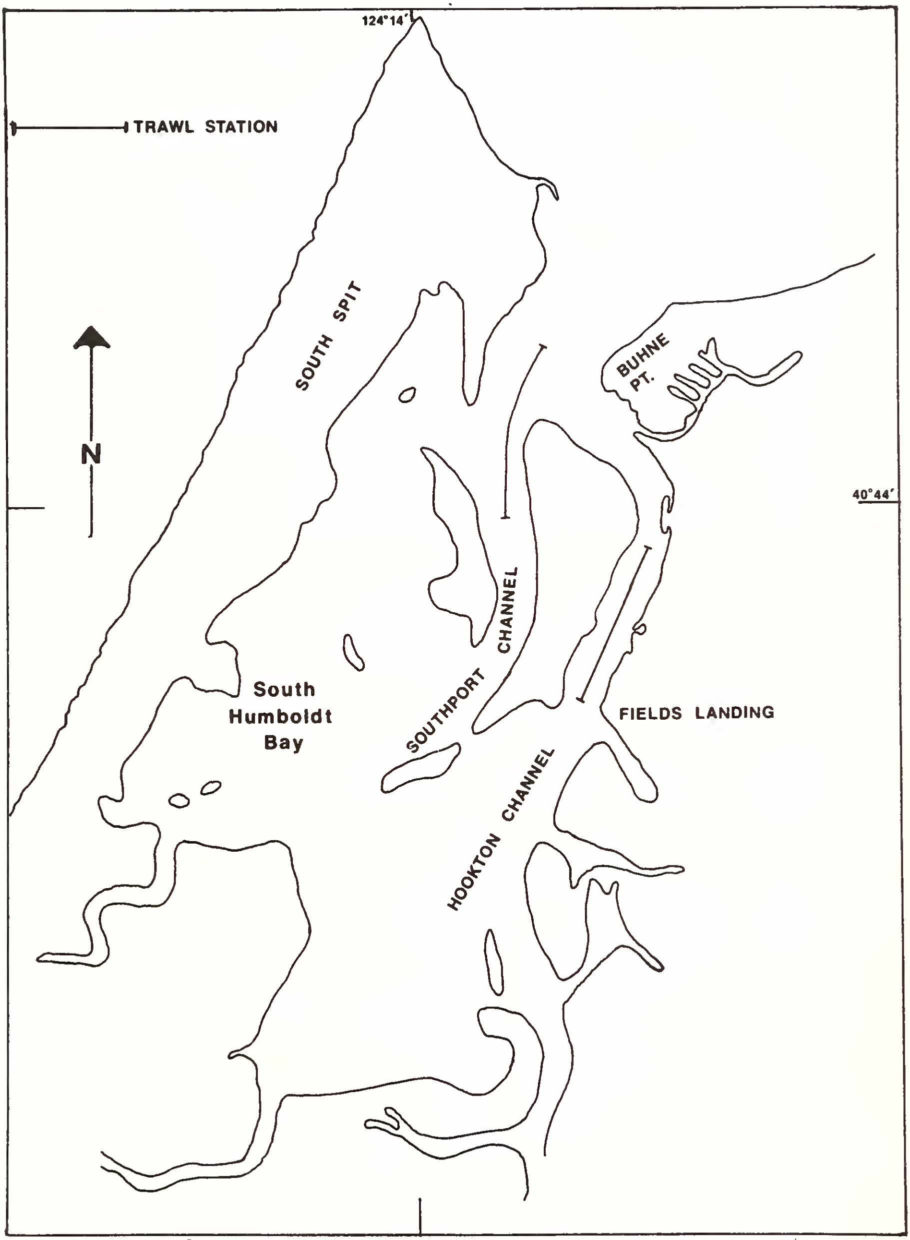

FIGURE 2. Humboldt Bay Dungeness crab trawl survey sites.

Hand operated ring nets, 3.3 ft (1 m) in diameter, with 1.2-in. (3-cm) mesh, were used to capture juvenile crabs for tagging. International orange Floy FT-67 anchor tags were inserted through the crab's carapace, at the epimeral suture, into the branchial chamber. A reward of $2.00 was paid for returned tagged crabs. Age and growth of individual year classes (YC) was determined from tag returns, in-field molting observations, and application of the size-frequency separation procedure of MacDonald and Pitcher (1979) to time series trawl and trap survey data.

The assigned birthdate for crabs of the year was set at January 1 (Poole 1967). Age of crabs at time of entry into the fishery and time of molt differ because northern California crabs molt from mid-summer to early fall, prior to the opening of the commercial crab season (normally Dec. 1). For example, a crab 2.9 years of age, when the commercial season opens, would have molted at approximately 2.7 years.

RESULTS

Crab Tagging

During the period 1972 to 1974 a total of 7,930 crabs was tagged (Table 1), 93 percent of which were less than 110 mm. Returns from commercial and sport fishermen over a 5-year period totalled 105 crabs. Time at liberty ranged from 11 days to 3.5 years. A total of 52 recaptured crabs failed to molt, 19 molted once, and 34 molted more than once. Size at age could be determined with certainty for 33 crabs (Table 2). Three crabs, 83, 95, and 98 mm when tagged, were captured a month later at 108, 120, and 115 mm, respectively, and were determined to be 1.6 years of age. One crab recovered at age 2.0 was 164 mm. Sixteen crabs, age 2.9 to 3.5, averaged 158.2 mm; 12 crabs, 4.0 to 4.6 years old, averaged 172.2 mm, and a 197-mm crab was 5.0 years of age when recovered. Average size of 1972-yc crabs, recovered at 2.9 to 3.3 and 4.0 to 4.3 years, was 151.7 and 167.7 mm, respectively. Crabs of the 1973 yc averaged 160.5 and 181.2 mm for ages 3.0 to 3.5 and 4.3 to 4.6 years.

TABLE 1. Summary of Crab Tagging

Location	*Number Tagged*	*Recoveries*	*Date*
Crescent City (CC)	2,856	8	July 73
	2	0	April 74
	1,918	40	June 74
Trinidad (T)	50	0	Aug. 73
	54	0	Dec. 73
	303	8	July 74
	53	0	Aug. 74
Mad River Transect (MRT)	522	2	Oct. 73
	354	28	Oct. 74
Humboldt Bay (HB)	124	0	June 72
	1,418	4	July 73
	22	0	April 74
	3	0	Aug. 74
Table Bluff Transect (TBT)	251	15	Oct. 74
	7,930	105	

TABLE 2. Tag Recoveries at Known Age and Size

Tag Location	Year Class	Tagging Size (mm CW)	Tagging Age (yrs)	Recovery Size (mm CW)	Recovery Age (yrs)
HB	1972	83	1.5	108	1.6
CC	1973	98	1.5	115	1.6
CC	1973	95	1.5	120	1.6
CC	1973	106	1.5	164	2.0
HB	1972	93	1.5	148	3.2
CC	1972	93	1.6	150	2.9
CC	1972	94	1.6	153	3.3
CC	1973	95	1.6	153	3.1
CC	1973	97	1.6	154	3.3
HB	1972	99	1.6	156	3.2
CC	1973	99	1.6	160	3.2
CC	1973	101	1.6	158	3.3
CC	1973	102	1.6	160	3.4
HB	1971	104	1.5	158	3.3
CC	1973	105	1.6	165	3.3
CC	1973	105	1.6	163	3.5
T	1973	106	1.6	165	3.4
CC	1973	108	1.6	167	3.2
HB	1971	109	1.5	160	3.3
CC	1973	129[1]	1.6	161	3.0
CC	1972	78	1.6	161	4.3
CC	1972	80	1.6	161	4.2
CC	1972	85	1.6	174	4.1
HB	1972	85	1.5	165	4.1
CC	1972	85	1.6	169	4.1
CC	1972	86	1.6	171	4.0
CC	1972	89	1.6	178	4.1
CC	1973	93	1.6	172	4.4
CC	1973	95	1.6	177	4.6
CC	1973	99	1.6	185	4.4
CC	1973	101	1.6	191	4.3
MRT	1972	103	1.9	163	4.1
CC	1973	92	1.6	197	5.0

[1] Soft.

Sizes for five recaptured crabs were estimated in inches by commercial fishermen, and those estimates are probably close to actual size. The age at date of tagging could not be determined for other recoveries because those crabs were beyond the size (110 mm) for confident year-class assignment (Table 3).

Field Observation of Molting Crabs

A mass molt of 1.6-year-old, 1973-yc crabs, in Crescent City Harbor, in July 1974, allowed us to capture 62 male crabs in the late stages of ecdysis. When molting was completed, the old shell was measured and the soft crab was placed, by itself, in a tub of sea water and allowed to expand for about 4 hours. A new measurement then was taken. Pre- and post-molt size ranges were 79–116 mm (pre) to 93–133 mm (post). Molt increments ranged from 12 to 23 mm and averaged 17 mm.

Ocean Surveys

The growth progression of several year classes of crabs was followed during a series of annual cruises conducted within the months of October, November, and December, 1972 to 1977 (Figures 3 and 4). A total of 35,264 Dungeness

TABLE 3. Tag Recoveries of Uncertain Age or Size

Tagging Location	*Year Class*	*Tagging* Size (mm CW)	*Tagging* Age (yrs)	*Recovery* Size (mm CW)	*Recovery* Age (yrs)
T	1973	102	1.6	6¼" [1]	3.3
CC	1973	107	1.6	6½" [1]	3.3
CC	1973	109	1.6	6½" [1]	3.3
CC	–	120	–	149	–
MRT	–	124	–	6¾" [1]	–
CC	–	129	–	159	–
CC	–	128	–	157	–
MRT	–	131	–	156	–
MRT	–	132	–	158	–
MRT	–	135	–	158	–
MRT	–	136	–	157	–
CC	–	137	–	168	–
T	–	131	–	6⅛" [1]	–
T	–	139	–	168	–
CC	–	139	–	169	–
MRT	–	141	–	171	–
MRT	–	141	–	170	–
MRT	–	142	–	173	–
MRT	–	151	–	176	–
T	–	152	–	180	–
MRT	–	155	–	181	–

[1] Measurement taken by fishermen in inches.

crabs was caught during that 6-year period (Tables 4 and 5). On some cruises, only a sub-sample of trawl-caught, early instars was measured because of their excessive numbers. During cruises from 1973 to 1977, male crabs were examined for the presence of mating marks (Figure 5). These marks, which are scratches on the inside of the chelipeds resulting from the mating embrace, are indicative of sexual activity. Old marks are yellow and fresh marks are white. Crabs with old mating marks in October or November have failed to molt during the normal time period and, thus are one instar smaller in size than the rest of the members of their year class. As expected, there were no crabs with fresh mating marks because mating normally occurs during spring and early summer, followed by ecdysis in late summer and early fall. Only crabs with old mating marks, those which failed to molt, were observed.

Results of the 1972 fall survey revealed an exceptionally strong 1972 yc. Male and female crabs 50 mm or less averaged 427.6 per trawl. Crabs larger than 50 mm were scarce in both traps and trawl. Clearly, this age group was isolated because of its unusual strength and weak preceding year classes. The 1973 cruise showed a sharp increase in 51 to 100-mm crabs which averaged 16.3 crabs per trawl. Legal-sized crabs (159 mm CW) were scarce (2.0/trap), as reflected in record low landings of 323,982 lb for the 1973–74 season, but sublegal crabs consisting of the 1971 and 1972 yc's (see Discussion for details of year class analysis) averaged 9.8 per trap. Crabs with mating marks ranged from 113 to 180 mm with a mean of 143 mm. In 1974, large numbers of crabs close to legal size were caught in trawls and traps. Crabs in traps were dominated by the 1972 yc. A small increase in the 1974–75 commercial landings to 1,400,485 lb was due primarily to approximately 28% of the 1972 yc attaining legal size at 3 years of age. The average size of mating-marked crabs in traps was 145.8 mm and ranged

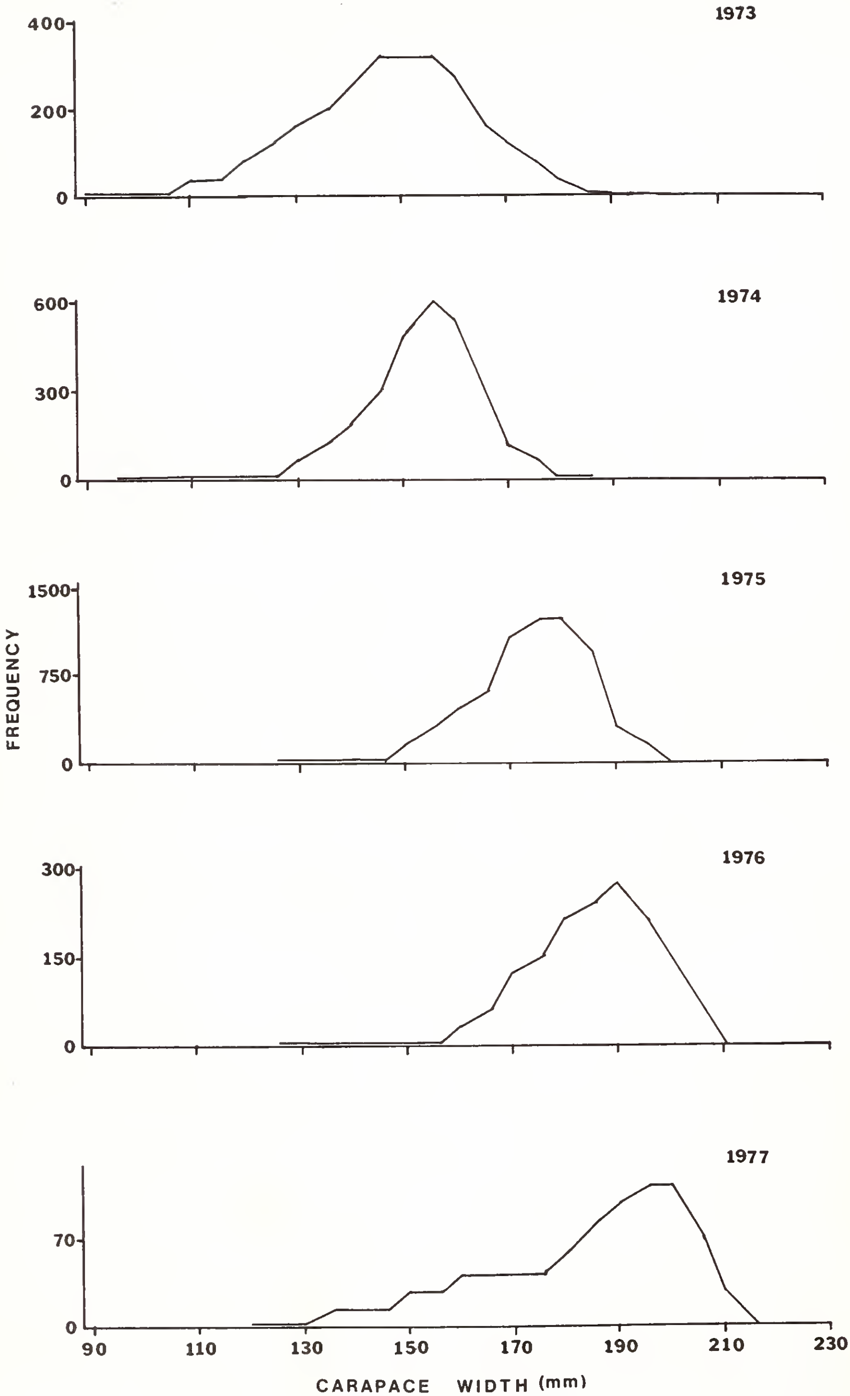

FIGURE 3. Size distribution of male Dungeness crabs, without mating marks, captured in traps during ocean surveys from 1973 to 1977.

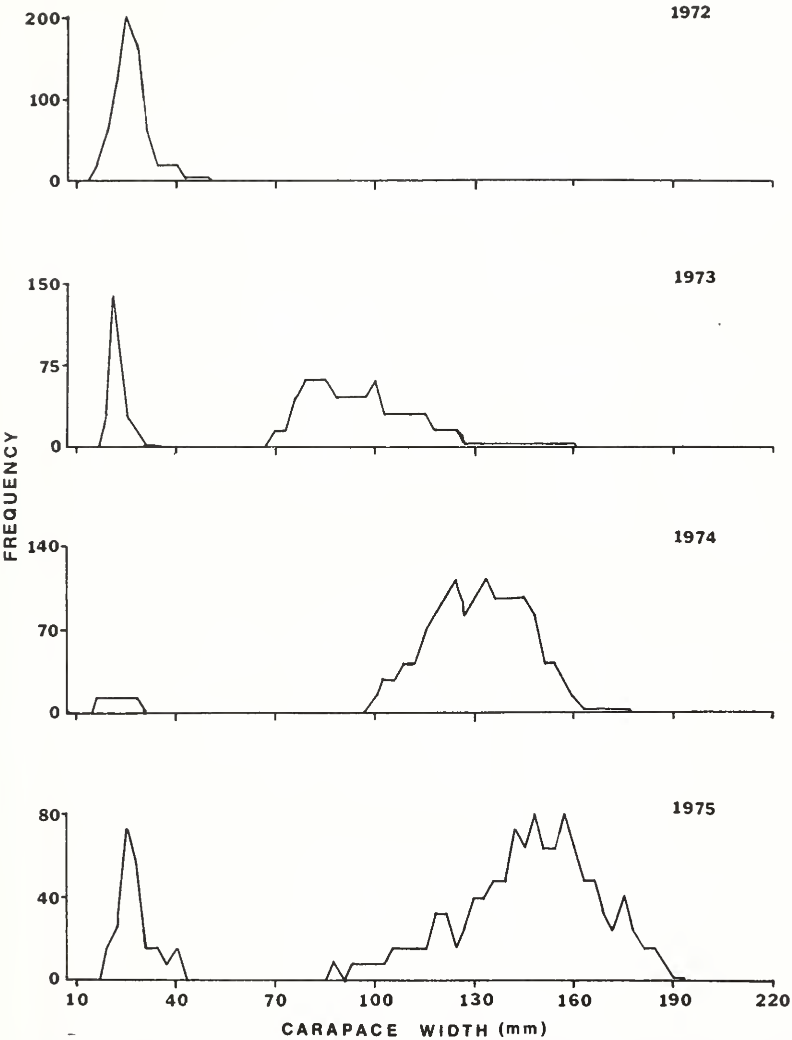

FIGURE 4. Size distribution of Dungeness crabs captured in trawls during ocean surveys from 1972 to 1975. Crabs in the 10 to 50mm range include males and females. The remainder are males only.

from 126 to 167 mm. The 1975 survey showed an overwhelming increase of legal-sized crabs captured in traps and trawls which resulted from the remainder of the 1972 yc attaining legal size at age 4 and about 60% of the 1973 yc recruiting at 3 years. Correspondingly, commercial landings increased to 15,381,870 lb. A total of 1,234 trapped crabs with mating marks averaged 151.9 mm and ranged from 125 to 179 mm. Only traps were set during the 1976 and 1977 surveys, but both surveys produced strong catches of very large crabs. In the 1976 season, carryover of the 1972 yc and full recruitment of the 1973 yc resulted in record commercial landings (24.8 million lb).

TABLE 4. Crab Survey Trap Data

Period	Total number of crabs	Mean catch/trap (males) < 159 mm CW	Mean catch/trap (males) ≥ 159 mm CW	Northern Calif. commercial landings (lb)
1972	588	0.7	2.3	1,046,245
1973	2,775	9.8	2.0	323,982
1974	4,022	8.8	1.9	1,400,485
1975	9,349	9.1	24.3	15,381,870
1976	1,541	0.6	11.6	24,811,936
1977	862	1.4	8.3	12,898,761

TABLE 5. Crab Survey Trawl Data[1] (Ocean Only)

Period	Total number of crabs	Mean catch/trawl[2] m & f ≤50 mm	m 51–100 mm	m 101–158 mm	m ≥159 mm	Commercial landings (lb)
1972	10,289	427.6	0.4	0.1	0.5	1,137,884
1973	1,967	21.6	16.3	7.5	0.0	323,982
1974	2,176	2.0	0.6	32.0	0.6	1,400,485
1975	1,695	22.0	1.1	37.0	12.4	15,381,870

[1] Only includes tows from 10 to 50 fm (18 to 91 m).
[2] m = male, f = female.

Humboldt Bay Survey

Trawling in Southport and Hookton channels in Humboldt Bay yielded juvenile crabs dominated by the 1972 yc. The average size of 1972 yc crabs (sexes combined) caught during December 1972 was 45 mm. These crabs had increased in size to an average of 66 mm in June 1973 (Figure 6). Bay trawling conducted in July, August, and September, 1973, yielded few crabs of the 1972 yc; however, smaller crabs, representing the 1973 yc, were apparent (Figure 7).

Distribution Mixture Analysis

Age (size) group parameters were calcuated from width-frequency data for cruises from 1972 to 1977 by using the separation procedure of MacDonald and Pitcher (1979). Crabs with mating marks were separated from those without marks in the trap catch analysis (Table 6); however, means and standard deviations of the trawl catch include crabs with mating marks (Table 7). Means for 0.9-, 1.9-, 2.9-, and 3.9-year-old 1972-yc trawl-caught crabs were 24.7, 93.8, 140.8, and 172.7mm, respectively. Trapped crabs of the 1972 yc averaged 133.5, 150.7, 176.1, and 188.6 mm for ages 1.9, 2.9, 3.9, and 4.5, respectively.

Instar Calculations

Regression slopes of molt increment data, gathered from molting observations and returned tagged crabs from northern California which had molted once, were compared to regression slopes for central California Dungeness crabs. There was no significant difference at the 95% confidence level, indicating that molt increment sizes for central and northern California are similar. Instar sizes for the 1972 yc (Table 8) were then calculated from the following equations (Collier 1983):

Male crabs with beginning carapace widths less than 100 mm:

$$X_{i+1} = 1.0529 + 1.2233X_i$$

Male crabs equal to or greater than 100 mm:

$$X_{i+1} = 19.532 + 1.0515X_i$$

Where: X_i is the width in mm of the i [th] instar.

A starting point of 150.7 mm for the 14th instar was used to calculate other instar sizes because there was more information for that instar than any other.

Calculated instar sizes were plotted in conjunction with the means of crabs of known age to produce a growth curve for the 1972 yc (Figure 8).

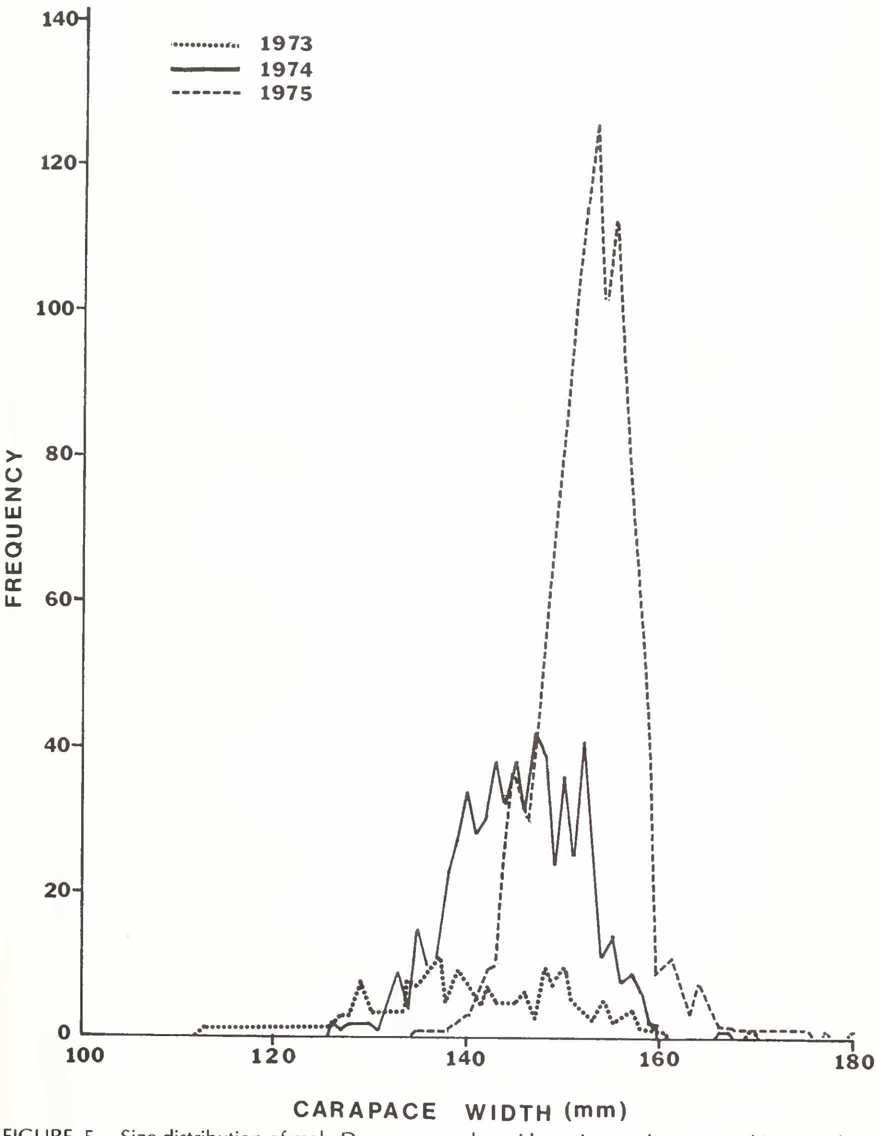

FIGURE 5. Size distribution of male Dungeness crabs, with mating marks, captured in traps during ocean surveys from 1973 to 1975.

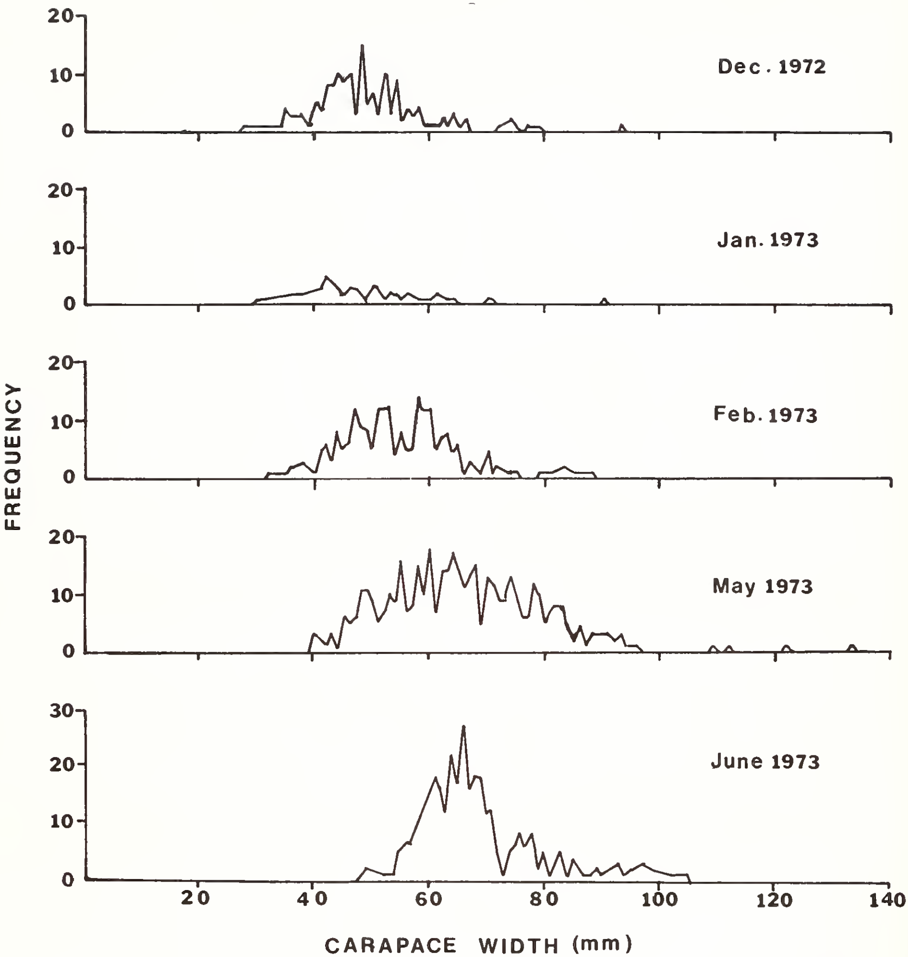

FIGURE 6. Size distribution of male and female Dungeness crabs captured in Humboldt Bay trawls, December 1972 through June 1973.

DISCUSSION

Age and growth analysis of Dungeness crabs is simplified if data are gathered from a year class which is isolated by its strength and has been preceded by weak year classes. Also, tag returns of known age and in-field molting observations provide definitive age and growth documentation while time series, width frequency data offer presumptive evidence. Comparative observations of seasonal commercial landings can relate intuitively to specific year classes provided enough definitive and presumptive data are available.

The discovery of an exceptionally abundant 1972 yc preceded by weak year classes presented the unique opportunity to document the age and growth of this single crab year class through tagging and annual ocean surveys. Most tagging occurred during early summer when large concentrations of 70 to 120 mm crabs were found in Humboldt Bay, an estuarine environment, and Crescent City Harbor, which has a greater oceanic influence. Monthly trawling in Hum-

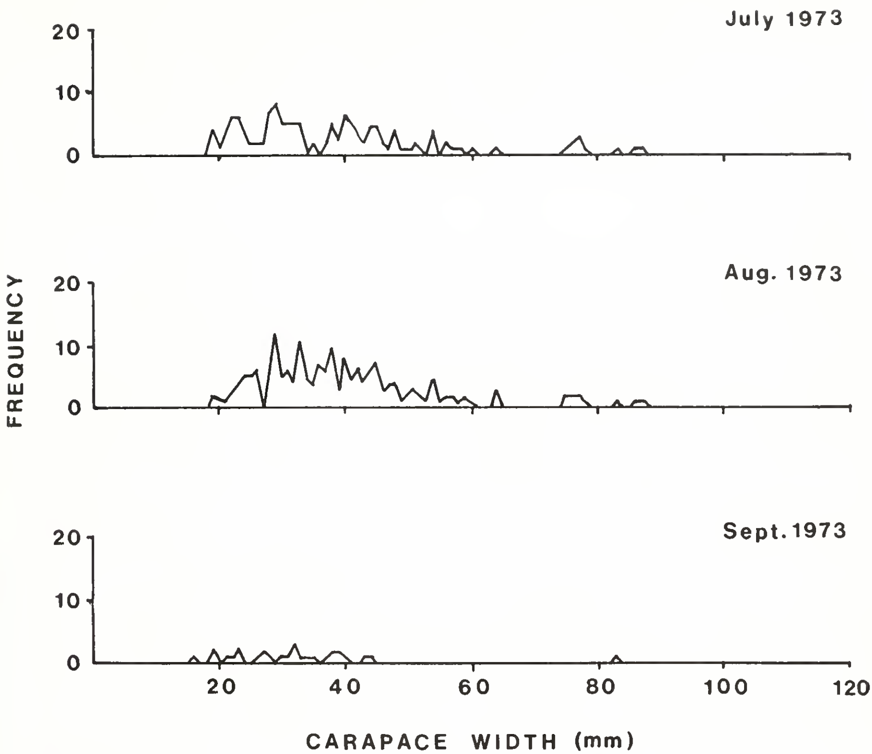

FIGURE 7. Size distribution of male and female Dungeness crabs captured in Humboldt Bay trawls, July through September 1973.

TABLE 6. Length Frequency Separation for Trapped Male Crabs

Year	*Age (YC)*	*Mean CW (mm)*	*SD*	*N*
		No Mating Marks		
1973	1.9(72)	133.5	14.6	1260
	2.9(71)	151.7	9.5	1234
	3.9(70)	171.3	5.7	131
1974	1.9(73)	110.6	27.4	136
	2.9(72)	150.7	11.0	2581
1975	2.9(73)	164.1	10.7	2821
	3.9(72)	176.1	6.9	3590
1976	3.9(73)	176.4	12.2	814
	4.9(72)	188.6	7.5	694
1977	3.9(74)	169.1	18.0	389
	4.9(73)	193.6	7.4	422
		Mating Marks		
1973	3.9(70)	143.0	11.0	195
1974	3.9(71)	145.8	6.4	631
1975	3.9(72)	151.9	4.6	1234

boldt Bay (Figure 6) showed that juvenile, 1972-yc crabs in early winter were larger than those observed in the ocean. Similar observations were made for the 1973 yc (Figure 7). Gotshall (1978) showed that in November, juvenile Humboldt Bay crabs were larger than ocean crabs, but after December growth

TABLE 7. Width Frequency Separation for Trawl-Caught Crabs

Year	Age (YC)	Mean CW (mm)	SD	Sex	N
1972	0.9(72)	24.7	4.89	m + f	645
1973	0.9(73)	21.3	2.7	m + f	491
	1.9(72)	93.8	15.9	m	740
1974	0.9(74)	23.3	6.0	m + f	89
	1.9(73)	120.8	11.5	m	820
	2.9(72)	140.8	10.1	m	645
1975	0.9(75)	26.8	5.8	m + f	483
	1.9(74)	122.8	16.8	m	322
	2.9(73)	149.7	11.4	m	645
	3.9(72)	172.7	8.4	m	144

TABLE 8. Comparison of Calculated Widths of Male Dungeness Crabs

Instar Number	Carapace Width (mm) [1] San Francisco Bay [2]	Northern California	Washington [3]	Queen Charlotte Islands [4]
1	7.3	6.7	5.0 to 7.0	6.5
2	10.7	9.3	8.8	9.4
3	14.2	12.4	11.7	12.9
4	18.4	16.2	15.7	17.3
5	23.6	20.9	22.0	22.6
6	29.9	26.6	28.4	29.1
7	37.6	33.6	34.7	37.0
8	47.0	42.2	44.1	46.6
9	58.6	52.7	55.8	58.4
10	72.7	65.5	68.0	72.7
11	90.0	81.1	84.6	90.2
12	111.2	100.2	105.9	111.5
13	136.5	124.8	129.2	137.1
14	163.0	150.7	154.9	164.5
15	190.9	177.9	–	193.7
16	220.3	206.5	–	224.9

[1] All measurements exclude spines.
[2,3,4] From Collier (1983).

slowed. An exodus of Bay crabs to the ocean in late summer was also noted. These observations imply that juvenile crabs in Humboldt Bay grow rapidly from time of metamorphosis through December, but slowly thereafter, with sizes by the following summer similar to ocean crabs of comparable age. Our tagging results revealed that Humboldt Bay crabs grew at a rate similar to crabs in Crescent City Harbor. Also, observations were made in mid-summer of actively molting crabs 79 to 116 mm in Crescent City Harbor, which attained sizes as large as 133 mm. One freshly molted, 129-mm crab tagged in that area was recovered subsequently at 161 mm and 3.0 years of age. Therefore, summer-tagged crabs 70 to 110 mm in size in Humboldt Bay, Trinidad Bay, and Crescent City Harbor were 1.5 to 1.8 years old.

Thirteen of nineteen tagged crabs recovered at ages 2.9 to 3.5 were from the 1973 yc. Recruitment to the fishery of a large portion of that year class at age 2.9 probably accounted for their domination of recoveries at that age. Chances for recovery of 3-year-old individuals from the slower growing 1972 yc would have been reduced because the majority of those crabs could escape from the commercial traps.

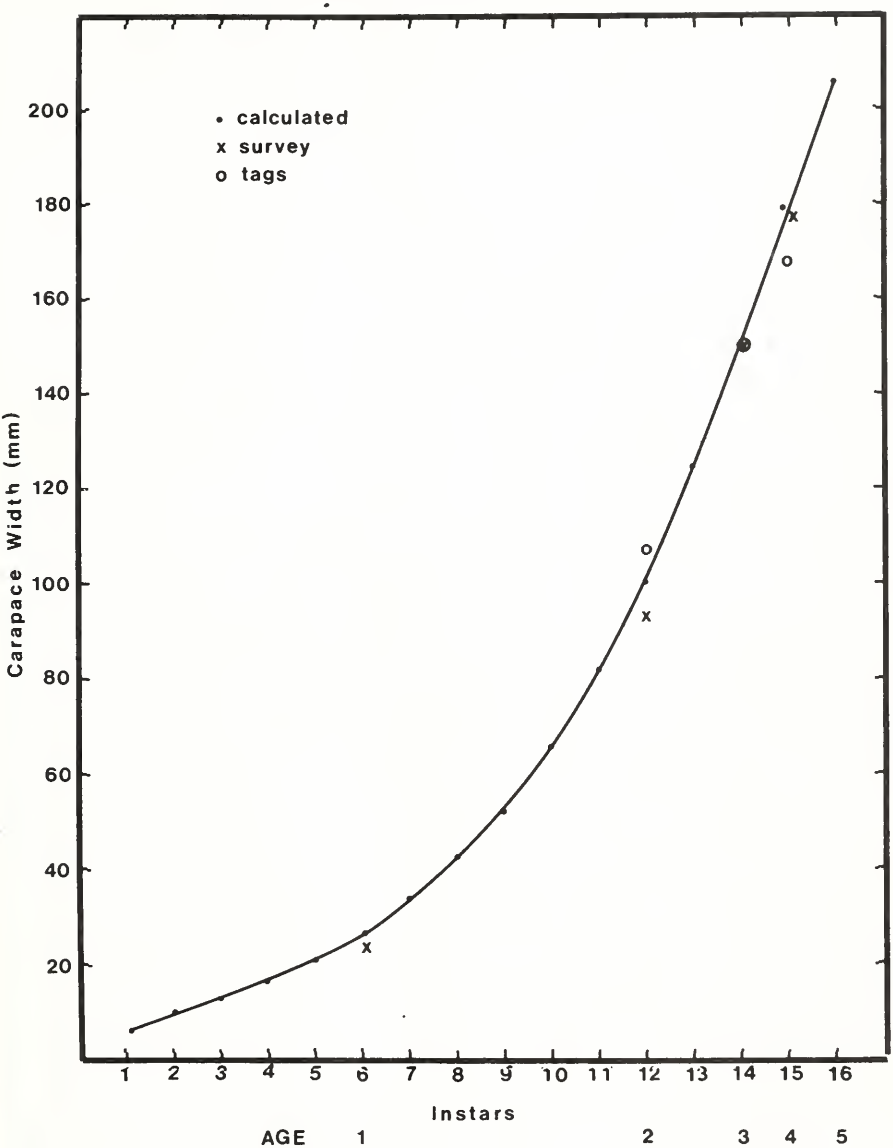

FIGURE 8. Male Dungeness crab growth curve for the 1972 yc. Data points are calculated instars and mean cw from tagging and survey data.

Early growth of the 1972 yc also can be traced from ocean trawl width frequency data which show a progression from a 24.7-mm average in November 1972 to 93.8 mm 1 year later at 1.9 years of age. The average size of 133.5 mm for trapped 1972-yc crabs in 1973 is biased due to gear selection of only the faster growing components of that group (Table 6).

Trap and trawl survey data from 1974 revealed the size composition of the 1972 yc at 2.9 years of age (Tables 6 and 7). The 10-mm difference in mean carapace widths of the 1972 yc may be attributed to the much smaller trawl

sample size. Size estimates from tag recoveries and mating-marked crabs agree with the trap data. Crabs of that age occupy a size range which can be selected by either gear type. Diamond (1983) demonstrated 100% retention of female crabs, 136 mm in width, in commercial traps with closed escape ports and 50% selection at 128 mm. Length-width ratios of male and female crabs differ; therefore, males of comparable length are approximately 142 mm and 132 mm, respectively, in width (Pacific Marine Fisheries Commission 1978). These data imply effective retention of male crabs as small as 132 mm by closed port traps. Escapement through crab pot mesh and entry tunnels by smaller crabs was minimized by short soaking times, usually less than 24 hours, and heavy baiting. Therefore, the trap mean of 150.7 mm is more representative than the trawl mean for 2.9-year-old crabs. Returns of tagged crabs in the 2.9- to 3.5-year age group may, however, be biased toward the high side because commercial traps have 108 mm escape ports which allow crabs less than 159 mm the opportunity to escape.

In the 1975 fall surveys the 3.9-year-old 1972 yc demonstrated two modes of growth (Table 6). One of the modes represented approximately 26% of the year class which did not molt during summer or fall 1975, as indicated by the presence of mating marks on 1,234 trapped crabs. These crabs averaged 151.9 mm, a reflection of the mean for that group at 2.9 years. The remainder, which had molted, averaged 176.1 mm.

Results of the 1976 survey are difficult to interpret because of overlap between the 1972 yc and 1973 yc, but very few mating-marked crabs were noted, demonstrating a low molt failure rate for the 1973 yc. Molt failure complicates the picture of size at age unless that failure can be identified. The presence of mating marks is a tool to make that differentiation. Poole (1967) noted from examination of male crabs for mating marks and shell fouling that 10–15% of male crabs retained their carapace for more than a year. Data presented here indicate considerable molt failure variability among year classes.

Distribution mixture analysis showed a mean difference of 13.4 mm between the 1972 and 1973 yc when 2.9 years old, but only 0.3 mm difference at 3.9 years. Interpretation of results in Tables 6 and 7 should be viewed with caution, especially for year classes other than 1972, which were not isolated. Tagging results (Tables 2 and 3) are necessary to verify growth rates of mixed year classes.

Our data show that 28% of the 1972 yc entered the fishery at 2.9 years of age and most of the remainder at 3.9 years. A minor amount would have entered at 1.9 and 4.9 years. Mixing of 2.9-year-old 1973-yc crabs with 3.9-year-old 1972-yc crabs makes separation difficult, but tag returns and distribution mixture analysis indicate rapid growth of the 1973 yc, with about 60% entering the fishery at 2.9 years of age.

Computed post-larval instars of the 1972 yc most closely matched sizes found by Cleaver (1949) in Washington where 15 instars were required to reach legal size. Calculated widths of crabs from Bodega Bay (Poole 1967), San Francisco Bay (Collier 1983) and the Queen Charlotte Islands (Butler 1961) showed attainment of legal size in 14 stages. Comparison of instar widths for Pacific coast crabs clearly demonstrates differences in growth rates which ultimately determine the percentage of legal-sized crabs in the 14th instar. The consequent

variation in recruitment ratios influences commercial harvest because of the weight difference between instars. A crab growing from 155 to 180 mm will increase in weight by 64% (Cleaver 1949). In some years, a large portion of a fast growing year class may be harvested in the 14th instar. That year class would ultimately yield fewer total pounds over its life expectancy than if it had been slower growing with fewer crabs recruited at the same stage. Only 28% of the 14th instar of the 1972 yc recruited during the 1974–75 crab season, which resulted in a small jump of landings from the previous record low season of 0.32 million pounds. Major recruitment of 15th-instar crabs during the 1975–76 season yielded a dramatic increase in landings exceeding 15 million pounds. Conversely, the faster growing, 2.9-year-old 1973 yc recruited about 60% of its members during the same season with an obvious lower yield in poundage to the fishery.

Most investigators have recognized the difficulty of assigning age to Dungeness crabs, but many have attempted it (Table 9). Age and growth in northern California (Table 10) is similar to that reported by Cleaver (1949) in Washington. A portion of the 14th instar is recruited 3 years after hatching and most of the remaining crabs enter the fishery in the 15th instar at 4 years. Growth in British Columbia (Butler 1961) is slightly slower, with little or no recruitment of the 13th instar at 3 years and the majority of the 14th instar recruited at 4 years. Size at age 5 years in northern California is close to that estimated in British Columbia (Butler 1961). No data were available for age 6, but this age probably is rarely attained because of fishing mortality.

TABLE 9. Comparison of Estimated Sizes at Age of Pacific Coast Male Dungeness Crabs

	Size (mm CW) at Age							
Area	*1 Yr*	*2 Yr*	*3 Yr*	*4 Yr*	*5 Yr*	*6 Yr*	*7 Yr*	*8 Yr*
British Columbia [1]	10	60	85	100	115	130	150	165
Queen Charlotte Island [2]	29.1	111.5	137.1	164.5	193.7	–	–	–
Washington [3]	30	95	150	175	–	–	–	–
Bodega Bay, Ca.[4]	63–94	133.1-151.9	152-170	–	–	–	–	–
San Francisco Bay, Ca.[5] ..	102	–	legal	–	–	–	–	–

[1] From MacKay and Weymouth (1935) (see discussion regarding validity).
[2] From Butler (1961).
[3] From Cleaver (1949).
[4] From Poole (1967).
[5] From Collier (1983).

TABLE 10. Size at Age of Northern California Male Dungeness Crabs

		Size (mm CW) at Age				
Year Class	*Data Source*	*1 Yr*	*2 Yr*	*3 Yr*	*4 Yr*	*5 Yr*
1972	Tagging	–	108.0	151.7	167.7	–
	Survey (no mating marks)	24.7	93.8	150.7	176.1	188.6
	Survey (mating marks)	–	–	–	151.9	–
	Computed Widths	26.6	100.2	150.7[1]	177.9	206.5
1973	Tagging	–	117.5	160.5	181.2	197.0
	Survey	21.3	120.8	164.1	176.4	193.6

[1] Starting point for instar calculations derived from survey data.

MacKay and Weymouth (1935) reported that British Columbia crabs attained legal size in 8 years, but Butler (1961) showed that their data were inconsistent with their estimates of age. Botsford (1984), in a cursory examination of a portion of unpublished data used for this report, concluded that northern California crabs are slow growing, with a larger portion of the crabs recruiting at 5 and 6 years of age. His conclusions are inconsistent with the results presented here as well as those of Cleaver (1949), Butler (1961), and Poole (1967).

This study has shown that male Dungeness crabs in northern California are, with minor exception, fully recruited at age 3.9. The percentage of crabs which enter the fishery at 2.9 years varies. Analysis of two strong year classes (1972 and 1973) showed that the 1972 yc was slower growing than the 1973 yc.

ACKNOWLEDGMENTS

I thank N. Nelson, W. Dahlstrom, L. Quirollo, J. Span, B. Bott, and the captains and crews of the N.B. SCOFIELD and BLUEFIN for field work assistance. G. Beyer, D. Hankin, J. Geibel, and N. Diamond provided invaluable aid in statistical analysis of the data. Technical advice was given by P. Collier, P. Wild, and D. Gotshall. R. Tasto critically reviewed the manuscript and offered many valuable suggestions. Special thanks go to all commercial fishermen who participated in the study.

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Calif. Fish and Game 73(1): 21–36 1987

POPULATION TRENDS, DISTRIBUTION, AND SURVIVAL OF CANADA GEESE IN CALIFORNIA AND WESTERN NEVADA, 1949–79[1]

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Distribution, migration patterns, harvest and survival rates were determined for approximately 33,000 Canada geese, *Branta canadensis moffitti,* banded in California and western Nevada from 1949 to 1979. The average fall population of Canada geese in northeastern California, 1952–79, was 21,446 geese. Northeastern California was the main harvest area with 57.5% of the kill occurring there. The Sacramento Valley, Delta and San Francisco Bay region are the main wintering areas for geese migrating from northeastern California, and harvest occurred primarily in the Sacramento Valley. About 22% of immature geese banded on nesting areas in northeastern California were harvested as subadults in Canada. There was no significant difference in recovery and survival rates between adult male and female Canada geese ($X^2=24.07$, d.f.$=27$, $P<0.05$). For all adult geese banded in northeastern California and western Nevada, mean band recovery rate was $9.12\pm0.41\%$ and survival rate was $71.71\pm0.78\%$. The adult survival rate was approximately the same for all banded cohorts with little annual variation, whereas band recovery rate varied annually and geographically. Immature geese banded at Honey Lake had a mean recovery rate of $14.49\pm0.82\%$ and a survival rate of $51.23\pm3.65\%$. Assuming a crippling loss of 15% and a band reporting rate of 50%, the Honey Lake adult mortality was 24.0% hunting and a 5.7% natural mortality.

INTRODUCTION

Geese of the Pacific population of Western Canada geese breed in southern British Columbia, northern and southwestern Idaho, western Montana, Washington, Oregon, northwestern Nevada and northeastern California (Krohn 1977). The pacific population is managed as five separate units (Pacific Flyway Management Plan, unpubl. rep.). This report is concerned with the unit encompassing southeastern Oregon, northeastern California and northwestern Nevada.

Canada goose banding was initiated in California in 1949 by the California Department of Fish and Game. Most banding occurred on nesting and molting areas of northeastern California and northwesten Nevada (Figure 1). The objectives of the study were to determine distribution, migration patterns and survival rates.

METHODS

The Canada goose breeding ground survey in northeastern California has been conducted in essentially the same manner since its inception in 1948. Each June geese were counted using aircraft. Counts on Klamath Basin NWRs were made by refuge personnel. All other counts were made by California Department of Fish and Game personnel.

Flightless geese were trapped by drive trapping and banded each June from 1949 to 1960. Thereafter geese were banded every third year except 1970, which

[1]Accepted for publication June 1986.

was the fourth year. On large lakes and reservoirs, geese were driven several miles to the trap site by boats directed by observers in an airplane. A year or two of banding was done in other locations (Figure 1) to learn how geese using these areas fit into the overall population in northeastern California.

Geese trapped on nesting areas mostly were immatures, whereas those trapped on molting areas predominantly were adults (Table 1). No distinction was made at the time of banding between adults of breeding age and subadults (1 and 2 year old birds). Geese were sexed by clocacal examination and recorded as adult males or females before banding except in 1951, 1973, 1976 and 1979 when sex was recorded as unknown. Immature geese were not sexed. Age (immature or adult) was determined by size and/or plumage. Male and female band recoveries were combined to determine migration routes.

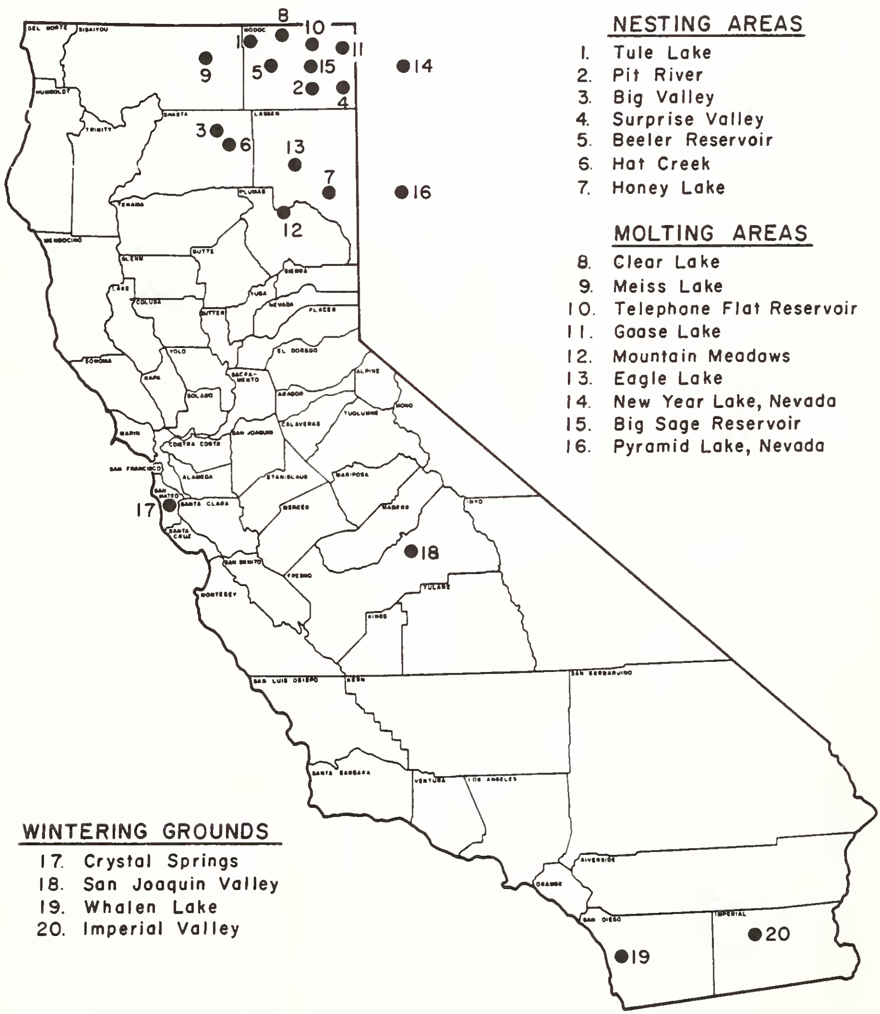

FIGURE 1. Canada goose banding stations in California and western Nevada.

TABLE 1. Area and Sample Size of Canada Geese Banded in California, 1949–1979

	Number banded				
	Adult		Unclassified		
Trap site	*male*	*female*	*adult*	*immature*	*Total*
Nesting areas					
Tule Lake	455	506	790	6,276	8,027
Pit River	87	76		574	737
Big Valley	47	44		428	519
Surprise Valley	17	18		174	209
Beeler Res.	8	11	113	312	444
Hat Creek	5	5		111	121
Honey Lake	541	588	523	3,511	5,163
Subtotal	1,160	1,248	1,426	11,386	15,220
Molting areas					
Clear Lake	1,241	1,310	477	118	3,146
Goose Lake	2,165	2,161	2,412	152	6,880
Mountain Meadows	199	238			437
Eagle Lake	121	126		2	249
New Year Lake, Nev.	373	429			802
Big Sage Res.	445	291	329	245	1,310
Pyramid Lake, Nev.	1,624	1,694			3,318
Meiss Lake			1,503		1,503
Telephone Flat Res.			363		363
Subtotal	6,168	6,239	5,084	517	18,008
Wintering grounds					
San Joaquin Valley	22	26			48
Crystal Springs	70	91			161
Imperial Valley			317		317
Whalen Lake			177		177
Subtotal	92	117	494		703
Grand total	7,420	7,604	7,004	11,903	33,931

Recoveries from birds shot or found dead during the period 1 September to 1 February were used for analysis, except for retraps. All percentages used in the migration section of this report are expressed as proportions of total recoveries from a particular banded sample rather than as traditional recovery rates (e.g., as proportions of the total birds banded). Thus, proportion of recoveries from various geographic locations were compared within and between samples.

The relationship between nesting and molting areas was determined by analysis of retrap data. Retrapped geese refers to geese trapped and banded in northwestern California and retrapped one or more years later either at the same or another site. Band numbers were recorded and geese released.

A contingency chi-square test for differences due to sex was computed for adult male and female geese. Because no significant difference was indicated (X2=24.07, d.f.=27, PO .05), male and female band recovery data were combined in the determination of recovery and survival rates.

Banding and recovery data were analyzed during methods of Brownie et al. (1976). Models 2 (adults only) and HO2 (young and adult) were used to estimate recovery and survival rate. The assumption of model HO2 used for Honey Lake data were (i) young and adults have different survival rates (ii)

survival rates are otherwise constant from year to year, and (iii) recovery rates are year-specific and age-specific. Model 2 assumes constant survival and time-specific recovery rates. Computer summaries of the recovery data were supplied by the U.S. Fish and Wildlife Service, Laurel, Maryland.

Band recovery data for banding done through 1960 was used to estimate band recovery and survival rates. Banding was done at three and four year intervals in the 1960s and 1970s. Three year survival rates would not be useful and also, data were sparse for this time period, so data after 1960 were not used.

RESULTS

Population Trends

The average fall population estimate, 1952–79 (1948–52 were deleted as being too variable), for northeastern California including the Klamath Basin NWRs was 21,440 geese, with a high of 27,030 in 1973 and a low of 14,180 in 1955. Surveys in the Klamath Basin have shown a steady decline, while there has been an increase in the remainder of northeastern California (Figure 2).

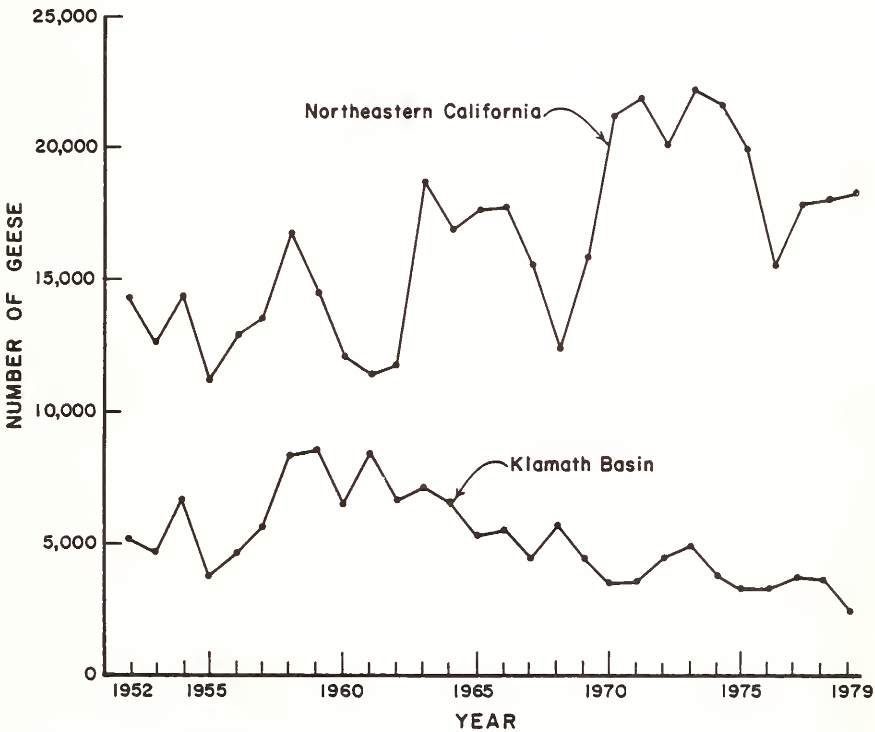

FIGURE 2. Yearly fall Canada goose population for northeastern California (not including Klamath Basin) and the Klamath Basin compiled from breeding ground surveys.

Distribution and Migration

Indirect band recovery data suggest approximately 57.5% of all banded geese harvested were shot in northeastern California, 8.3% in the Sacramento Valley, 7.5% in the Delta-San Francisco Bay area, 1.9% in the San Joaquin Valley, and 10.0 in Canada (8.6% from southeastern Alberta and 1.0% from southwestern

Saskatchewan, Table 2). The remaining 14.8% were harvested in other areas of California and the Pacific Flyway and in a few instances outside of the Pacific Flyway. Of geese banded on nesting areas, 65.5% were recovered in California and 15.3% in Canada as compared to 85.2% and 4.9% respectively for geese banded on molting areas. The difference may result from the high proportion of young in the nesting area samples. Nonbreeding, yearling Canada geese move north on molt migrations in greater numbers than other age classes. The assumption is that those geese recovered in Canada went there to molt. Those geese harvested north of California, especially in Idaho and Washington, appear to be enroute from Canada to California.

TABLE 2. Distribution of Indirect Band Recoveries from 23,071 Canada Geese Banded on Nesting and Molting Areas in Northeastern California, June 1949–60, 63, 66, 70, 73, 76*

	Nesting areas		*Molting areas*		*Combined totals*	
Recovery areas	*No.*	*%*	*No.*	*%*	*No.*	*%*
Calif. (Northeast)	984	50.5	1359	63.8	2343	57.5
Calif. (Sacto. Valley)	148	7.6	192	9.0	340	8.3
Calif. (San Francisco Bay)	100	5.1	208	9.8	308	7.5
Calif. (San Joaquin Valley)	32	1.6	47	2.2	79	1.9
Calif. (Inyo-Mono)	8	0.4	1	0.1	9	0.2
Calif. (Imperial Valley)	1	0.1	2	0.1	3	0.1
Wash. (Central)	44	2.2	17	0.8	61	1.4
Wash. (East)	35	1.8	6	0.3	41	1.0
Oregon (East)	26	1.3	10	0.4	36	0.9
Oregon (South)	123	6.3	101	4.7	224	5.5
Idaho (North)	9	0.4	6	0.3	15	0.3
Idaho (South)	42	2.1	20	0.9	62	1.5
Idaho (East)	15	0.8	4	0.2	19	0.4
Nevada (West)	21	1.1	34	1.6	55	1.3
Br. Col. (Interior)	6	0.3	2	0.1	8	0.2
Alberta	260	13.3	91	4.3	351	8.6
Saskatchewan	29	1.5	10	0.5	39	1.0
Montana	19	1.0	4	0.2	23	0.5
S. Dakota	11	0.6			11	0.2
Colorado	5	0.3	5	0.2	10	0.2
Other Areas +	30	1.7			39	1.5
Total Recovered	1948		2128		4076	
Percent Recovered		100.0		100.0		100.0

* Not including Honey Lake or Pyramid Lake
+ Areas with ≤ 0.1% band recoveries are: North Coast, South Coast and Imperial Valley of California, Southern Nevada, Utah, Arizona, Northwest Territories, Manitoba, North Dakota, Wyoming, Kansas, Nebraska, Texas and Missouri.

The four main harvest areas within northeastern California are (i) Honey Lake to Susanville (30.1%), (ii) Pit River from Likely north to Alturas and west to Bieber (24.4%), (iii) Klamath Basin of California and Oregon (17.3%) and (iv) California side of Goose Lake (6.3%). The remaining 21.9% harvest was distributed on less important goose areas of northeastern California. Most of the harvest in the Sacramento Valley occurs in the center of the valley where the best waterfowl habitat is located. Harvest also occurred near foothill lakes and reservoirs, especially on the east side of the valley. Within the San Francisco Bay-Delta harvest area, Suisun Marsh and South San Francisco Bay accounted for the majority of the harvest. Most of the harvest in the San Joaquin Valley occurred between Los Banos and Stockton and east into the foothills. Geese wintering south of Merced were from out of state.

Data from winter banding in southern California (Table 3) suggest no interchange of wintering geese between northern and southern California. For lesser snow geese, *Anser caerulescens caerulescens,* (Rienecker 1965) and American Wigeon, *Anas americana,* (Rienecker 1976), there was one migration into northern California from the north and northeast, and another into southern California from farther east than the route into northern California. There was little interchange of birds between these two areas. Southern California was unimportant as a wintering area for Canada geese breeding in northeastern California, but it was of major importance to goose populations breeding in Wyoming, Utah, and to a lesser extent, Colorado.

TABLE 3. Distribution of Indirect Band Recoveries from 494 Canada Geese Banded in Winter in Southern California (Imperial Valley 1967–1969 and Whalen Lake, Oceanside, 1977)

	Bands recovered	
Recovery areas	*No.*	*%*
Calif. (South Coast)	5	5.2
Calif. (Inyo-Mono)	1	1.0
Calif. (Imperial)	30	31.3
Idaho (South)	19	19.8
Idaho (East)	2	2.1
Nevada (South)	3	3.1
Utah (North)	18	18.8
Utah (South)	4	4.2
Arizona (West)	1	1.0
Arizona (South)	1	1.0
Alberta	1	1.0
Saskatchewan	3	3.1
Wyoming	4	4.2
Montana	3	3.1
Colorado	1	1.0
Total Recovered	96	
Percent Recovered		99.9

During the 29 years of study, there appeared to be no significant shift in harvest from one area to another.

Although most of the harvest of Honey Lake banded geese took place in northeastern California (63.3%), many geese wintered within the triangle of Reno, Walker Lake and the Carson Sink of western Nevada (22.5%) compared to 5.4% in the Central Valley (Table 4). Geese from Nevada's Pyramid Lake exhibit the same general pattern (Table 4).

The area of southeastern Alberta and southwestern Saskatchewan is often referred to as a "staging area" for geese migrating south (Grieb 1970). California geese that migrate to Canada to molt use this same area enroute back to California.

Of geese banded in northeastern California and harvested in Canada, approximately 81% of the reported harvest took place by the end of October (Table 5). Also, as the reported harvest decreased in Canada, it increased in the Central Valley of California.

Geese that spent the summers in northeastern California remained until the ponds and reservoirs froze over before moving to milder weather of the Central Valley. However, some spent the winter in northeastern California in mild weather.

TABLE 4. Distribution of Indirect Band Recoveries from 8,088 Canada Geese Banded on the Honey Lake Nesting Area and the Pyramid Lake Molting Area, June 1949–60, 63, 66, 70, 73, 76

	Honey Lake		*Pyramid Lake*		*Combined totals*	
Recovery areas	*No.*	*%*	*No.*	*%*	*No.*	*%*
Calif. (Northeast)	575	63.3	276	45.5	851	56.1
Calif. (Sacto Val)	21	2.3	23	3.8	44	2.9
Calif. (S.F. Bay)	24	2.7	19	3.1	43	2.8
Calif. (San Joaquin Val.)	4	0.4	12	2.0	16	1.0
Calif. (Inyo-Mono)	8	0.9	10	1.6	18	1.1
Wash. (Central)	4	0.4			4	0.3
Wash. (East)	4	0.4			4	0.3
Oregon (East)	3	0.3	1	0.2	4	0.3
Oregon (South)	12	1.3	3	0.5	15	1.0
Idaho (South)	3	0.3			3	0.2
Nevada (West)	204	22.5	250	41.2	454	29.9
Nevada (East)	4	0.4			4	0.3
Alberta	24	2.7	7	1.1	31	2.0
Saskatchewan	7	0.8	1	0.2	8	0.5
Montana	2	0.2	2	0.3	4	0.3
Iowa	2	0.2	2	0.3	4	0.3
Other Areas *	8	0.8	1	0.2	9	0.7
Total Recovered	909		607		1516	
Percent Recovered		99.9		100.0		100.0

* Areas with ≤ 0.1% band recoveries are: south coast California, eastern Idaho, western Arizona, interior British Columbia, Manitoba, Colorado and Michigan.

TABLE 5. The Monthly Distribution of Canada Goose Band Recoveries from Birds Banded in Northeastern California and Recovered One or More Years Later*

	Harvest Areas					
	Canada		*Northeastern California*		*Central Valley California*	
	No.	*%*	*No.*	*%*	*No.*	*%*
September +	159	43.2				
October	140	38.0	490	22.9	21	3.2
November	30	8.2	615	28.7	54	8.2
December			667	31.2	298	45.2
January +			244	11.4	229	34.7
Date Unknown	39	10.6	123	5.8	58	8.7
TOTAL	36	100.0	2139	100.0	660	100.0

* Does not include geese banded at Honey Lake and Pyramid Lake.
\+ September and January not full months during hunting season.

Some subadult geese tended to migrate away from their natural breeding ground during their second and third year of life. During their second hunting season 21.8% were reported recovered in Canada (Table 6). Fewer were recovered in Canada the third year (17.6%) and even less for the average of the fourth year and over (12.4%). It is assumed that they returned to northeastern California as breeders during their third or fourth nesting season.

There was a significant difference in distribution of harvest between geese banded as immatures and those banded as adults in northeastern California (Table 6). By comparing indirect band recoveries (third year and over after banding for adults and fourth year and over for immatures, thus removing the bias imposed by the migration of subadults) fewer geese originally banded as immatures were harvested in northeastern California compared to geese banded

TABLE 6. A Comparison of the Distribution of Reported Harvest for Canada Geese Banded as Adults and as Immatures on the Nesting Areas of Northeastern California 1949–76*

Year recovered	*Adult*									*Immature*								
	Northeastern Calif.			*Canada*			*Other areas*			*Northeastern Calif.*			*Canada*			*Other areas*		
	No.	*%*		*No.*	*%*		*No.*	*%*		*No.*	*%*		*No.*	*%*		*No.*	*%*	
Direct	146	78.9		0	0.0		39	21.1		751	76.3		0	0.0		233	23.7	
2	83	69.2		6	5.0		31	25.8		214	34.8		134	21.8		267	43.4	
3	52	61.9		7	8.3		25	29.8		173	48.3		63	17.6		122	34.1	
4	36	70.6		4	7.8		11	21.6		114	54.3		30	14.3		66	31.4	
5	28	73.7		2	5.2		8	21.1		69	50.4		16	11.7		52	37.9	
6	10	55.5	66.7	3	16.7	7.9	5	27.8	25.4	52	61.2		11	12.9		22	25.9	
7	7	77.8		0	0.0		2	22.2		35	62.5	57.6	8	14.3	12.4	13	23.2	30.0
8	7	58.3		2	16.7		3	25.0		24	64.9		1	2.7		12	32.4	
9	8	80.0		0	0.0		2	20.0		17	85.0		2	10.0		1	5.0	
10 & Over	12	66.7		1	5.6		5	27.7		41	62.1		8	12.1		17	25.8	

* Does not include geese banded at Honey Lake and Pyramid Lake.

as adults (57.6% vs. 66.7%). This was offset by more immature banded birds being harvested later as adults in Canada (12.4%) than was found for geese banded as adults in northeastern California but recovered in Canada (7.9%).

In the Honey Lake-Pyramid Lake population, very little loss occurs to other harvest areas such as Canada (Table 7). The population is semiresident with approximately 90% of recoveries coming from northeastern California (mostly Lassen County) and western Nevada. Only 1.2% of the adults and 5.2% of the immatures were recovered in Canada.

Sex Ratio

The sex ratio of Canda geese trapped in northeastern California was close to 1.1. Of the 15,024 adult geese that were sexed, 51% were females. Except for a slight difference in size, there is no visual difference between sexes to cause the hunter to be selective. The sexes migrate together, and the male remains with the female throughout the nesting and brooding period. Chapman, Henny and Wight (1969) stated there is little, if any, differential natural mortality between sexes in the dusky Canada goose, *B.c. occidentalis,* population. They estimate the fall population to be made up of 50.3% females. Dimmick (1968) observed a sex ratio of 1.2:1 in favor of males in a sample of 333 molting Canada geese at Turbid Lake, Wyoming. Imber (1968) found in a New Zealand population of Canada geese that 45.5% of 14,379 banded adults were males. He theorized that males were more vulnerable to hunting than females because of their leadership of flights and their larger size, or both. He also stated that they had greater natural mortality than females.

Relationship of Nesting to Molting Areas

Tule Lake and Clear Lake geese (Table 8) were apparently of the same flock, Clear Lake being the molting area for the Tule Lake geese. Only five geese out of approximately 1,700 trapped on Meiss Lake had previously been banded on other areas; all from the Klamath Basin. Since harvest of these geese occurred primarily in Shasta and Scott Valleys (southwest of Meiss Lake), geese also may have nested there. Goose Lake had a close relationship with Pit River nesting geese. Geese from the Pit River-Alturas nesting area used Goose Lake and Big Sage Reservoir as molting areas. They are the closest large bodies of permanent water on which geese have been trapped. The Big Valley nesting area is also in the Pit River drainage, approximately 80 km southwest of Alturas. Geese using this area molt on Big Sage Reservoir, Telephone Flat Reservoir, Goose Lake and Clear Lake. Of 363 geese trapped at Telephone Flat Reservoir (1979), 12 had been banded at previous times at other locations. Eight geese were originally banded on Big Sage Reservoir, three on Modoc NWR and one on Beeler Reservoir. All these areas are relatively close to Telephone Flat Reservoir.

Two years of banding on New Year Lake, Nevada, produced only one California retrap (Goose Lake), so this flock was not a part of the California breeding population. Recoveries suggest, however, these geese move to northeastern California and southern Oregon after molting, and then to the Central Valley during the latter part of the hunting season. Approximately one third of the harvest of this flock comes from Oregon in the Goose Lake-Warner Valley area. This suggests this might be its breeding area.

The Warner Mountains on the east side of Modoc County divide geese molting in the area of Clear Lake, Big Sage Reservoir, Telephone Flat Reservoir

TABLE 7. A Comparison of the Distribution of Harvest for Canada Geese Banded as Adults and as Immatures at Honey Lake, California, 1950–76

Year recovered	Adult												Immature											
	Northeastern Calif.			Nevada			Canada			Other areas			Northeastern Calif.			Nevada			Canada			Other areas		
	No.	%		No.	%		No.	%		No.	%		No.	%		No.	%		No.	%		No.	%	
Direct	118	65.9		42	23.5		0	0.0		19	10.6		349	68.4		127	24.9		0	0.0		34	6.7	
2	56	66.7		22	26.2		2	2.3		4	4.8		104	55.1		56	29.6		8	4.2		21	11.1	
3	48	57.8		21	25.3		2	2.4		12	14.5		92	64.3		30	21.0		7	4.9		14	9.8	
4	43	67.2		16	25.0		1	1.6		4	6.2		51	64.6		11	13.9		4	5.1		13	16.5	
5	26	68.4		6	15.8		0	0.0		6	15,8		38	67.9		11	19.6		4	7.1		3	5.4	
6	18	75.0	67.3	6	25.0	21.7	0	0.0	1.2	0	0.0	9.8	17	60.7		7	25.0		3	10.7		1	3.6	
7	12	80.0		2	13.3		0	0.0		1	6.7		12	52.2	65.4	6	26.1	19.0	1	4.3	5.2	4	17.4	10.4
8	6	85.7		0	0.0		0	0.0		1	14.3		10	62.5		4	25.0		0	0.0		2	12.5	
9	8	80.0		2	20.0		0	0.0		0	0.0		11	91.7		0	0.0		0	0.0		1	8.3	
10 & Over	10	76.9		2	15.4		0	0.0		1	7.7		12	70.6		5	29.4		0	0.0		0	0.0	

TABLE 8. Canada Goose Retrap Records as an Indicator to the Relationship Between Nesting and Molting Areas in Northeastern California

Banding Site: Tule Lake * (nesting area)	
Retrapped site:	
Tule Lake	424
Clear Lake	70
Goose Lake	16
Pit River	12
Crystal Spr.	1
Nevada	2
Utah	1
Idaho	1
Washington	1
Banding Site: Pit River, Alturas * (nesting area)	
Retrapped site:	
Pit River	10
Goose Lake	17
Big Sage	10
Clear Lake	1
Eagle Lake	1
British Columbia	1
Illinois	1
Banding Site: Big Valley * (nesting area)	
Retrapped site:	
Goose Lake	14
Clear Lake	8
Big Sage	2
Banding Site: Surprise Valley * (nesting area)	
Retrapped site:	
Surprise Valley	3
Pyramid Lake	20
Goose Lake	1
Banding Site: Honey Lake * (nesting area)	
Retrapped Site:	
Honey Lake	193
Pyramid Lake	252
Eagle Lake	3
Mt. Meadows	1
Pit River, Alturas	2
Goose Lake	5
Clear Lake	2
Tule Lake	1
Washington	1
Missouri	1
Banding Site: Clear Lake * (molting area)	
Retrapped site:	
Clear Lake	137
Tule Lake	46
Goose Lake	18
Surprise Valley	2
Pit River	1
Big Sage	1
Crystal Spr.	10
Banding Site: Goose Lake * (molting area)	
Retrapped site:	
Goose Lake	297
Pit River	22
Big Valley	6
Tule Lake	3
Clear Lake	3
Big Sage	10
Eagle Lake	2
Mt. Meadows	2
Honey Lake	2
Pyramid Lake	3
Washington	1
Oregon	1
Banding Site: New Year Lake, Nev.* (molting area)	
Retrapped site:	
New Year Lake	36
Goose Lake	1
Oregon	1
Banding Site: Big Sage * (molting area)	
Retrapped site:	
Big Sage	2
Goose Lake	2
Pit River, Alturas	6
Banding Site: Meiss Lake * (molting area)	
Retrapped site:	
Meiss Lake	122
Lower Klamath	1
Banding Site: Pyramid Lake, Nev.* (molting area)	
Retrapped site:	
Pyramid Lake	137
Honey Lake	74
Surprise Valley	2
Eagle Lake	1
Illinois	1
Texas	1
Colorado	1
Washoe Lake, Nev.	3
Banding Site: Crystal Springs * (wintering area)	
Retrapped site:	
Clear Lake	5
Goose Lake	2

* See Table 1 for number of geese banded.

and Goose Lake from those molting on Pyramid Lake, Nevada. Although Goose Lake is a comparatively short flight over the Warner Mountain range from Surprise Valley, and New Year Lake to the northeast is even closer, retrap data show that Surprise Valley geese fly south to Pyramid Lake for molting.

Honey Lake geese used Pyramid Lake, but there were Honey Lake retraps reported from many areas of northeastern California. Honey Lake is one of the largest lakes in northeastern California, yet the Lake was not used as a molting area since it is comparatively shallow and occasionally dries up.

Indirect band recoveries (bands recovered in subsequent band recovery years following the year of banding) show, except for Honey Lake, Canada geese from northeastern California used the same general wintering areas in the Central Valley and San Francisco Bay-Delta area. Not all Canada geese had strong traditional ties to only one molting area. Geese banded on molting areas were sometimes retrapped on other molting areas in later years.

Survival and Harvest Recovery Rates

Band recoveries from adult geese banded in northern California and western Nevada showed a mean band recovery rate of 9.12±0.41% and a survival rate of 71.17±0.78% (Table 9). However, for adults banded only on molting areas of Clear Lake and Goose Lake, the data show a mean recovery rate of 7.84±0.19% and a survival rate of 71.71±0.89%.

The 9.12±0.41% recovery rate for all adults was diluted by molting area bandings and inflated by breeding area geese. The 10.43±0.68% mean band recovery rate (Table 9) found for the breeding adults banded at Honey Lake represented all breeding geese in California. Their survival rate of 70.30±1.63% was similar to that of molting geese bandings. Using Lack's method of calculating survival, Hanson and Eberhard (1971) estimated survival for adults nesting along the Columbia River during the 1950s to be 68.5%. Using Hickey's composite-dynamic method, Chapman et al. (1969) calculated a survival rate of 67.1% for adult dusky Canada geese. However, these survival rates cannot be regarded as accurate comparisons since the methods used were inappropriate (Burnham and Anderson 1979).

TABLE 9. Survival and Mortality Summary of Canada Geese Banded in Northeastern California and Western Nevada, 1949–1960*

Area	*Band recovery rate*	*Survival rate*	*Harvest mortality rate*	*Natural mortality rate*
Adult geese in northeastern California and Western Nevada	9.12	71.17	20.94	7.89
Adult geese from Clear and Goose Lakes	7.84	71.71	18.08	10.21
Adult geese from Honey Lake	10.43	70.30	23.99	5.71
Immature geese from Honey Lake	14.49	51.23	35.50	13.27

* In percent, based on 50% band reporting rate and 15% crippling loss.

The immature geese banded at Honey Lake had a mean recovery rate of 14.49±0.82% and a survival rate of 51.23±3.65% (Table 9). Thus, immatures were 1.4 times more likely to be harvested than adults and had about a 50-50 chance for survival through the first year.

The sample sizes of geese banded on nesting areas other than Honey Lake were too small to compute recovery and survival rates for each area and too variable when areas were pooled. Therefore, it is assumed that the survival rate

of all immatures reared in California was similar to that found for immatures reared in Honey Lake Valley.

Annual fluctuations in recovery rate are generally similar for all areas. For example, 1954 was a high recovery rate year, with Honey Lake adult recoveries estimated 13.58±1.45% compared to the mean recovery rate of 10.43±0.68%, and an adult recovery rate of Clear and Goose Lakes of 11.63±0.97% compared to the mean rate of 7.84±0.29%. The hunting season of 1960, by contrast, was a low year with an estimated rate of 5.71±1.02% for Honey Lake adults and a rate of 5.59±0.56% for Clear Lake and Goose Lake birds. This suggests that whatever caused the fluctuating recovery rates affected all of northeastern California.

The daily bag limit on Canada geese in northern California was two per day from 1949 to 1953 and three per day from 1954 to 1978. In 1979 the bag limit was lowered to two per day in northeastern California and one per day in the Central Valley-Delta-San Francisco Bay area. The increased bag limit from two to three did not affect an increase in recovery rates (Table 10). Neither were the variations in season length reflected in band recovery rates. The averages for the two periods (10.12% for 1949–1953 and 8.41% for 1954–1960) indicate a decrease in the band recovery rate, the opposite of what would be expected. Some factors other than bag limit and season length, e.g., weather and band reporting rate, influenced band recovery rates during 1949–1960.

TABLE 10. Comparison of Band Recovery Rates to Bag Limits and Season Length for Adult Canada Geese Banded in Northeastern California and Western Nevada, 1949–60

Year	*Band Recovery Rate*	*Average*	*Bag limit*	*Season length*	*Average*
1949	14.91		2	40	
1950	8.83		2	44	
1951	8.66	10.12	2	60	56
1952	10.62		2	70	
1953	7.58		2	68	
1954	11.75		3	72	
1955	8.46		3	72	
1956	8.42		3	80	
1957	7.88	8.41	3	95	82
1958	7.70		3	95	
1959	9.58		3	94	
1960	5.08		3	67	

DISCUSSION

Habitat on Klamath Basin NWRs has remained essentially the same throughout the study period. Tule Lake and Lower Klamath NWRs are heavily hunted, and it is possible that these geese are being overharvested. Unfortunately, banding data sufficient for analysis are not available for Klamath Basin geese to permit computation of recovery and survival rates to indicate whether these geese are being overharvested. Rienecker (1985) stated, however, while there were not statistically significant differences between the Goose Lake, Telephone Flat and Meiss Lake molting areas in number of geese shot, there was a difference between molting areas and the Tule Lake nesting area. Tule Lake geese sustained a greater harvest than geese from the three molting areas. Adequate data from other nesting areas for comparison with Tule Lake were, however, not available from his study of neck-collared geese.

Biologists agree that Canada geese have a strong homing instinct for only one nesting area. Consequently, it is assumed that the 7.9% of adults banded on the breeding grounds in northeastern California and recovered in Canada went there to molt rather than to nest. They were probably geese incapable of breeding or were unsuccessful nesters.

Of 21,325 adult geese banded in northeastern California and western Nevada during the molt, none were recovered in Canada the same year of banding, thus indicating migration took place prior to molting. Sterling and Dzubin (1967) stated that molt migrations have been documented for *B.c. maxima* and *B.c.moffitti* from their midcontinent breeding ranges to the subarctic tundras of the Northwest Territories. They defined molt migration as the summer movements of geese from their breeding grounds to specific molting areas.

Although no California bands have been recovered in Canada above lat 61° N, it is generally thought that California geese molt in a remote area of the Northwest Territories where bands are unlikely to be recovered (Turner, pers. comm.). Most band recoveries come from southern Alberta; however, this was not the molting area for California geese (Turner, pers. comm.). No banded geese from California have ever been retrapped in Alberta during molting. Presumably, after molt, they move down from the Northwest Territories to southern Alberta. Since most of the geese had left Canada by the end of October and few were recovered in Central Valley before December, they apparently spend most of the interim in northeastern California.

I assume most geese on molting areas were nonbreeding subadults. In a study on marked geese, Craighead and Stockstad (1964) found that roughly one third of two year olds and all of three year olds breed. Presumably subadults would not likely be retrapped on the molting area in the following years since they would be of breeding age and consequently would be on nesting areas. An exception would be geese banded on molting areas as one year olds and retrapped the following year as two year olds. However, some geese trapped on molting areas were retrapped on the same area in later years. Since molting areas also contain a few nesters, some retrapped geese could have used the molting area as a nesting area. It appears, however, that molting areas are usually poor nesting areas because the lack of good nesting habitat forces the geese to nest along the shore which, in turn, makes the nest more vulnerable to predation. Some geese retrapped on molting areas were probably unsuccessful nesters or had lost their young to more dominant adults from the related nesting area. Another possibility that could contribute to the high number of retraps from geese banded on molting areas would be geese no longer capable of breeding. However, the breeding capability of the average goose is much longer than their average life span in the wild. Therefore, a goose in the wild unable to breed because of old age would be a rarity.

Winter banded geese in Imperial Valley were retrapped in later years as molting adults in Wyoming and Utah. Thus, there is no relationship between the breeding population of northeastern California and the wintering population of southern California. Reports on western Canada goose populations in Washington (Hanson and Eberhardt 1971), Oregon (McLaury 1973, unpub. rep., Malheur National Wildlife Refuge), and the Rocky Mountain region (Krohn 1977) also support this assumption.

Since a large percentage of geese banded on Clear and Goose Lakes were believed to be subadults, they would influence recovery and survival rates of

geese banded on these areas. Presumably, they might have a higher rate of band recovery because they are not as old and experienced as breeding adults and, therefore, not as wary. However, the data did not indicate this presumption to be correct. In fact, there was a lower recovery rate for these geese than for all adult geese banded in northeastern California and western Nevada. There was no significant difference in survival rates. The lower recovery rate suggests that as subadults they were not as vulnerable to hunting as are breeding geese, which probably means they inhabit areas with less hunting pressure than those areas occupied by breeders. It also implies that as subadults they were, in fact, just as wary as older geese. Sightings of color marked Canada geese from northeastern California indicate municipal reservoirs in the San Francisco Bay area, which are closed to hunting, were important wintering areas particularly for subadults (Rienecker 1985).

Since adult goose survival rates were similar on all areas and constant from year to year while recovery rates varied, hunting seemed to be compensatory rather than additive for natural mortality. Anderson and Burnhan (1976) in their study of the mallard, *Anas platyrhychos,* concluded that for kill rates below some threshold, hunting mortality is largely compensated for by other forms of mortality.

Assuming the crippling loss to be about 15% as determined from steel-lead shot studies conducted by the U.S. Fish and Wildlife Service (C. Kimball, pers. comm.) and the band reporting rate to be approximately 50% (Henny 1967), hunter kill rate and natural mortality rate were estimated for Canada geese in California. The 28.3% mortality rate for Clear and Goose Lakes geese was divided in to 18.1% hunter kill and 10.2% natural mortality (Table 9). The Honey Lake adult mortality of 29.7% is reduced to 24.0% hunter kill rate and 5.7% natural mortality. This indicates that hunting has replaced a larger portion of this natural mortality in the Honey Lake geese than in Clear Lake and Goose Lake birds. The hunter kill rate for Honey Lake geese could not be increased much more without affecting the survival rate of these birds. However, the band reporting rate of 50% was not based on factual data and therefore the hunter kill rate and natural mortality can only be regarded as approximations.

Management Implications

Northeastern California is the area of most importance in the management of California's Canada geese. This area offers several factors favoring the continuation of an adequate survival rate for Canada geese: (i) Northeastern California is part of the great basin, is sparsely populated and has only a few all-weather roads. It is a long drive from any of the populated areas of California, so a hunting trip requires more than one day, thus limiting the number of hunters using the area. (ii) Canada geese do not concentrate in large flocks in Northeastern California as do lesser snow geese, cackling geese, *B.c. minima,* and white-fronted geese on their way to the wintering grounds of the Central Valley. They are usually in small flocks, sometimes not more than a family in size, and are distributed throughout most of northeastern California where water and grazing are available. (iii) California is favored with many species of ducks and geese that concentrate in areas which afford the hunter "action", thus taking pressure off the Canada goose. Many Canada geese are shot incidentally to hunting other species of waterfowl. However it is suspected that a high percentage of the

goose harvest is taken by a small percentage of ardent goose hunters. (iv) The nesting season spans a relatively long period of time and therefore is not as critical as the "boom or bust" nesting seasons of the Arctic. Even in the poor years in northeastern California, some young are always produced, unlike "bust" years in the Arctic when no young are raised, such as occurs periodically in the lesser snow goose population. (v) The increasing interest by state, federal and private organizations in the welfare of the Canada goose has resulted in construction of water impoundments, nesting islands and nesting platforms.

ACKNOWLEDGMENTS

I wish to express appreciation to D. Anderson for his guidance in the statistical phase of the study and for reviewing the manuscript. Thanks are also due to M. Miller, D. Connelly, B. Turner, W. Krohn and B. Deuel for helpful comments on the manuscript, and to personnel of the California Department of Fish and Game, Nevada Department of Fish and Game and Klamath Basin NWRs for assistance in the trapping and banding program.

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Calif. Fish and Game 73(1): 37–44 1987

FOOD HABITS OF LARGE MONKEYFACE PRICKLEBACK, *CEBIDICHTHYS VIOLACEUS* [1]

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The stomach contents of 170 large (>30 cm SL) monkeyface pricklebacks, *Cebidichthys violaceus,* caught by poke-poling during low tides in the rocky intertidal zone near Dillon Beach, California were examined. Since most of the stomachs were full or nearly so, feeding probably takes place chiefly during ebbing tides. Sixty species of macroalgae, one angiosperm, and one colonial diatom were identified from the contents of 161 stomachs. Rhodophytes and chlorophytes predominated, while phaeophytes were absent, probably due to differences in palatibility and/or differences in assimilation potential. *Iridaea cordata* was found in 77% of the stomachs and was the sole species in 10%. Seasonal differences were striking with the number of species per stomach increasing from winter to summer. In winter, lower intertidal macroalgae comprised most of the diet, while in spring and summer, upper intertidal species became more common. A comparison of these data with previous work suggests that there may be a spatial separation in the foraging zones of large and small monkeyface pricklebacks.

INTRODUCTION

This study began when the second author found macroalgae in the stomachs of large monkeyface pricklebacks, *Cebidichthys violaceus,* caught by poke-poling at low tide in the rocky intertidal zone in the vicinity of Dillon Beach, California. We examined the stomach contents of this fish to gather information on its food habits.

Fitch and Lavenberg (1971) stated that macroalgae were taken incidentally as the fish foraged for animal foods. Burge and Schultz (1973), after analyzing the stomach contents of six large fish taken at Diablo Canyon, California, reported that the monkeyface prickleback was an "active algivore". Later, Montgomery (1977) presented data on small fish, documenting a change of foods from animals to plants when fish exceeded 5–7 cm standard length (SL). Recently, a series of papers based on intensive field and laboratory studies of fish (mostly <20 cm SL) taken near Piedras Blancas, California, presented detailed information on stomach contents, selectivity, food preferences, food availability, seasonal diets and assimilation of macroalgae (Edwards 1981, Edwards and Horn 1982, Horn, Murray, and Edwards 1982, Horn 1983, Barton 1983). These papers reported that fish shift from animal to plant foods at $\geq$ 4 cm SL.

We examined stomachs from large (>30 cm SL) fish taken between late December and early August and found that they contained a wide variety of macroalgae. We speculate on the correlation of apparent seasonal changes in the fish's diet with the seasonal abundance and life histories of seaweeds taken as food as well as with the feeding habits of the fish.

[1] Accepted for publication July 1986.

MATERIALS AND METHODS

A total of 170 stomachs from 30–71 cm SL fish provided by fishermen between 28 December 1981 and 8 August 1984 was examined. Most (98%) of the fish were caught between February and July on the rocky coast 0.8 to 2.5 km north of Dillon Beach, California (lat 39° 15′ N, long 123° 00′ W). Seven were taken farther north at Bodega Head (lat 38° 18′ N, long 124° 01′ W) and six were taken from the south at Pacifica (lat 37° 38′ N, long 122° 30′ W). Eighty-five were taken at tides of −1.0 to −2.0 ft and 86 were caught at tides between −0.3 and −0.9 ft.

Only nine of the 170 stomachs were empty and most of the other 161 were full or nearly so. They were preserved in 4% formalin/seawater or by freezing until examined. The contents were removed, identified, and plant materials were dried on herbarium paper.

Information on the vertical distribution and life form of the eight species of macroalgae most commonly found in the stomachs was compiled from personal observations with reference to Abbott and Hollenberg (1976).

RESULTS

Plants Foods

Sixty species of macroalgae were identified, of which 55 were rhodophytes and five were chlorophytes. The angiosperm, *Phyllospadix torreyi,* was also recorded, as well as a colonial diatom (Table 1). Phaeophytes were absent.

TABLE 1. Plant Foods in 161 Stomachs of *C. violaceus*
(R = Rhodophyte, C = Chlorophyte, A = Angiosperm)

	Division/#Stomachs
Iridaea cordata	R/125
Ulva lobata	C/ 28
Porphyra perforata	R/ 28
Mastocarpus papillatus	R/ 28
Gastroclonium coulteri	R/ 22
Botryoglossum farlowianum	R/ 22
Cryptopleura violacea	R/ 20
Hymenena flabelligera	R/ 22
Cryptosiphonia woodii	R/ 19
Cladophora columbiana	C/ 16
Callophyllis pinnata	R/ 14
Phyllospadix torreyi	A/ 12
Rhodoglossum roseum	R/ 12
Prionitis lyallii	R/ 10
Ptilota filicina	R/ 9
Callophyllis violacea	R/ 9
Plocomium cartilagineum	R/ 9
Microcladia borealis	R/ 7
Cryptopleura lobulifera	R/ 7
Polyneura latissima	R/ 7
Ulva taeniata	C/ 6
Rhodoglossum affine	R/ 6

Halymenia californica	R/	6
Pikea californica	R/	5
Endocladia muricata	R/	5
Erythrophyllum delesserioides	R/	5
Gigartina canaliculata	R/	5
Mastocarpus jardinii	R/	5
Microcladia coulteri	R/	5
Gigartina corymbifera	R/	5
Enteromorpha intestinalis	C/	5
Odonthalia floccosa	R/	4
Farlowia mollis	R/	4
Rhodomela larix	R/	4
Polysiphonia sp.	R/	4
Prionitis lanceolata	R/	4
Gelidium coulteri	R/	4
Corallina vancouveriensis	R/	3
Sarcodiotheca gaudichaudii	R/	3
Dilsea californica	R/	3
Schizymenia pacifica	R/	3
Neoptilota hypnoides	R/	3
Ahnfeltia plicata	R/	2
Gigartina volans	R/	2
Gracilaria sjoestedtii	R/	2
Neoptilota californica	R/	2
Nienburgia andersonii	R/	2
Callophyllis crenulata	R/	2
Porphyra lanceolata	R/	2
Centroceros clavulatum	R/	2
Iridaea flaccida	R/	2
Gelidium purpurascens	R/	1
Neoptilota densa	R/	1
Pterosiphonia dendroidea	R/	1
Rhodymenia californica	R/	1
Stenogramme interrupta	R/	1
Gymnogongrus linearis	R/	1
Pogonophorella californica	R/	1
Ceramium sp.	R/	1
Cryptopleura corallinara	R/	1
Enteromorpha linza	C/	1

Many plants were whole and relatively undigested. However, there was a considerable amount of gelatinous material at the posterior part of 23 (14%) stomachs. The structure of tissue layers in this material revealed that it was derived from *Iridaea cordata,* which was also present anteriorly.

Iridaea cordata occurred in 125 (77%) of the stomachs and was the sole species in 16 (10%). Seven other macroalgae were found in more than 20 (12%) stomachs. The remaining species occurred much less frequently (Table 1).

A majority (62%) of the stomachs contained 1–3 species of plants, 33% contained 4–7 species, and 7% contained 8–11 species (Figure 1). Different patterns are evident if the stomach samples are sorted into three seasons of collection (winter, 28 December through 31 March; spring, 16 April–17 May; summer, 21 June–08 August).

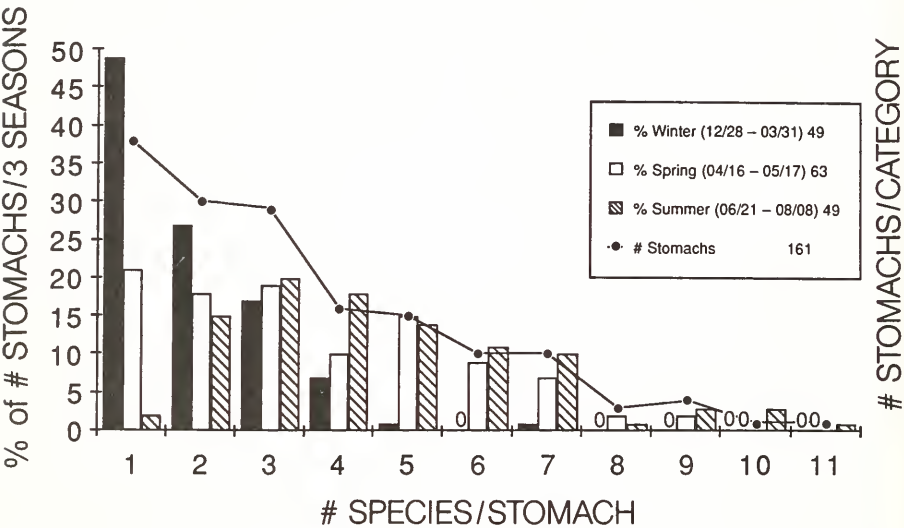

FIGURE 1. Percent of stomachs compared with number of species per stomach by season. Dates of season and sample size given.

The curve representing the winter stomach contents is similar to that of the total sample, but starts very high with 48% of 49 stomachs containing a single species, and drops off steeply with only two stomachs containing more than four species. The contents of 63 spring stomachs are similar to those of the total sample with 57% containing one to three species, 38% containing four to seven species, and 6% containing eight to 11 species. The contents of 44 summer stomachs show a very different pattern. Only 35% of the stomachs contain one to three species, 50% have four to seven species and 12% have eight to 11 species. The 2% of the summer stomachs containing a single species contrasts sharply with the 48% of the winter stomachs in the same category.

Data on the eight most common macroalgae found in more than 13% of the stomachs are presented in Table 2. These include seven rhodophytes (all perennial except the summer annual *Porphyra perforata*) and one chlorophyte (*Ulva lobata*), a summer annual.

In winter, *Iridaea* is a strong dominant (73%). *Botryoglossum, Cryptopleura,* and *Hymenea* are present in appreciable amounts (13–24%). In contast, *Porphyra, Mastocarpus, Ulva,* and *Gastroclonium* compose less than 1% of the diet. In spring, *Iridaea* is again dominant (69%), but the other seven species are found in roughly equal proportions (15–23% each). The frequency of *Ulva* jumped from 0% in winter to 20% in spring. In summer, *Iridaea* continues to dominate (75%), and there is a sharp decline (from 15–20% to 4–8%) in the low intertidal to subtidal plants, *Hymenena, Cryptopleura,* and *Botryoglossum.* The incidence of *Gastroclonium* (13%) decreases in frequency from spring to sum-

mer with a concomitant increase (21–27%) in the frequency of the upper intertidal species *Mastocarpus, Porphyra* and *Ulva lobata.*

TABLE 2. Eight Species of Macroalgae (in > 13% of 161 stomachs) Ranked According to Tidal Level: Showing Divisions, Life Form, and % Occurrence In the Total Sample and by Seasons

Species (Division)	*Tide level*	*Life form*	*% Occurrence* Total	Winter (Dec.–Mar)	Spring (Apr–May)	Summer (June–Aug)
Porphya perforata (R)	HI	Sp-Su Ann.	19	< 1	23	23
Mastocarpus papillatus (R)	HI	Su Per.	16	< 1	21	27
Ulva lobata (C)	MI-S	Sp-Su Ann.	17	0	20	31
Gastroclonium coulteri (R)	MI-S	Per.	12	< 1	23	13
Iridaea cordata (R)	MI-S	Per.	73	74	69	75
Botryoglossum farlowianum (R)	LI-S	Per.	13	19	15	6
Cryptopleura violacea (R)	LI-S	Per.	17	22	20	8
Hymenena flabelligera (R)	LI-S	Per.	12	13	20	4

(R) = Rhodophyte
HI = high—intertidal
MI = mid—intertidal
LI = low—intertidal
S = subtidal

(C) = Chlorophyte
Sp = spring
Su = summer
Ann. = annual
Per. = perennial

Animal Foods

Twenty-six stomachs contained invertebrate animal foods in trace amounts (Table 3). Four stomachs (3%) contained substantial amounts of animal material as follows: one was nearly full of the ascidian *Archidistoma ritteri,* one contained 59 colonies of the ascidian *Distalpia occidentalis,* one contained 2 cm^3 of *Distalpia* sp., and one was nearly full of small unidentified eggs.

TABLE 3. Animal Foods in 161 Stomachs of *C. VIOLACEUS* (26 stomachs contained items)

Taxon	*# Stomachs*	*Amount*
Hydroids		
Aglaophenia sp.	1	Trace
Unident.	9	Trace
Ascidians		
Distaplia occidentalis	1	59
Distaplia sp.	2	2 cm^3
Aplidium sp.	1	Trace
Archidistoma ritteri	1	5 cm^3
Archidistoma sp.	1	Trace
Unident.	2	Trace
Bryozoans	2	Trace
Crustaceans		
Idotea stenops	1	1
Polycheria sp.	1	1
Heptacarpus sp.	1	Trace
Unident.	2	Trace
Unident. eggs	1	5 cm^3

DISCUSSION

The high proportion (161 out of 170) of stomachs containing food, most of which was undigested, indicates that the fish were caught during or after their optimal feeding time. Since fishermen work the low tides, preferring the first one to two hours following the ebb, we infer that the fish forage chiefly during the ebbing tide.

This study clearly demonstrates that large monkeyface pricklebacks are herbivorous. The small amount of animal material found in the stomach contents consisted of sessile invertebrates common in the rocky intertidal, eggs which were laid on or among seaweeds, or small animals adhering to seaweed surfaces. These findings agree with those of Horn et al. (1982) who found that animal foods make up less than 2% (by weight) of the total diet and could well be incidental. Our samples contained even less animal material, possibly because the fish were larger than those studied by Horn.

The preponderance of rhodophytes and chlorophytes over other divisions of algae, especially phaeophytes, in the diet has been reported before (Burge and Schultz 1973, Barton 1983, Horn et al. 1982). Edwards and Horn (1982) and Horn et al. (1985) documented the assimilation of nutrients from red and green macroalgae by the monkeyface prickleback. Horn et al. (1985) found markedly lower levels of carbon assimilation from brown algae. The tough texture of intertidal brown algae (Lobel 1981), their indigestible wall components (Montgomery and Gerking 1980) and the presence of chemical compounds that might act as anti-herbivore defenses (Ragan and Jensen 1978, Steinberg 1980, Geiselman and McConnell 1981, Steinberg in press) may explain these results.

Our samples showed that the extracellular polysaccharides (carrageenans) in *Iridaea cordata* were affected by the digestive process, so that the tissue layers delaminated into a gelatinous mass. The other plants were relatively intact and often whole. Digestion must be independent of mechanical disruption (maceration or grinding) in the feeding process.

The wide variety of seaweeds (60 species) found in the stomachs suggests that the monkeyface prickleback eats the most common and abundant plants among the presumably more digestible rhodophytes and chlorophytes. Although we did not quantify the availability of individual seaweed species in the vicinity of Dillon Beach, we documented a change in the composition of the diet with season.

In winter, most of the stomachs contained only a few species of seaweeds, and nearly half contained solely *Iridaea.* This finding is consistent with observations that fewer species are available and/or that a few species dominate in biomass during winter. Among the upper intertidal species *Porphyra* and *Ulva* are annuals that do not occur in abundance during winter while *Mastocarpus* decreases in biomass in winter storms, eroding back to perennial basal crusts. The four species which comprise most of the winter diet are perennial rhodophytes that occur in the lower intertidal and subtidal throughout the year, suggesting that the monkeyface prickleback forages most successfully in deeper waters during winter. *Iridaea* is by far the dominant food in this season.

In spring, a more diverse assemblage is available at all tidal levels. Although *Iridaea* is still dominant, more than 20% of the stomachs contained more than six species. In summer, a majority of the stomachs contained several species,

reflecting a peak diversity of available species during summer. However, *Iridaea* continued to dominate. The fact that the upper intertidal species are ingested more commonly in summer than in spring, along with the sharp decrease in the ingestion of deeper water rhodophytes, such as *Hymenena, Botryoglossum,* and *Cryptopleura,* suggests that the fish find ample foraging in the upper intertidal. The decline in occurrence of *Gastroclonium* in the stomach samples, which may be due to its tendency to burn off in its upper range during summer low tides, is another indication of more time spent foraging in the upper tidal zones, since the subtidal *Gastroclonium* populations are as abundant in summer as in spring.

In contrast to these findings, Horn et al. (1982) report that *Ulva lobata,* an annual chlorophyte, dominates the diet of monkeyface pricklebacks at Piedras Blancas in all seasons, and that perennial plants are selected less but become important during winter in the absence of preferred annuals. In our study, *Ulva* is the second most common seaweed in spring and summer, and not significantly more than the next lower ranked algae, *Porphyra* and *Mastocarpus.*

We surmise that differing preferences, i.e., *Iridaea* vs. *Ulva,* may be a result of the difference in the size classes of the fish studied. Horn et al. (1982) sampled fish that were from 4.4–22.7 cm SL, while our fish ranged from 30–71 cm SL. It is possible that smaller fish are unable to harvest and ingest these large, relatively tough, perennial plants, and select the thinner, more delicate *Ulva.* Such preferences may therefore be independent of seasonal or latitudinal availability of macroalgae.

Barton (1983) documents the differential distribution according to size of monkeyface pricklebacks at Piedras Blancas with smaller individuals occurring higher in the intertidal zone. The foraging areas of large and small fish could thus be spatially separated, contributing to or resulting in different diets characteristic of various size classes. We note that plant food species ingested by small pricklebacks listed by Horn et al. (1982) occur chiefly in the upper intertidal zone, while the bulk of plants reported in our study occur in the lower intertidal and subtidal, especially in winter and spring.

We have observed a 38 cm SL fish in an aquarium at Bodega Marine Laboratory feed on *Iridaea.* When a blade was dropped into the aquarium, the fish bit one end and rapidly whirled its body and the blade, stopping to swallow the entire piece in one action accompanied by flapping opercula. This vigorous feeding style also accounts for the high number of whole plants found in the stomachs.

ACKNOWLEDGMENTS

Seventeen poke-poling fishermen provided specimens in addition to 31 caught by the second author. E. Keegan, Santa Rosa, and G. Madsen, Dillon Beach, were most helpful. K. Watson provided data on the contents of four stomachs from Bodega Head. C. Hand, Bodega Marine Laboratory, and J. West, University of California, Berkeley, provided laboratory space. The first author thanks West and P. C. Silva, University Herbarium, University of California, Berkeley, for reading the manuscript. The animal materials were identified by D. P. Abbott, University of Hawaii, Honolulu, and T. Chess, National Marine Services, Tiburon, to whom we are grateful.

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Calif. Fish and Game 73(1): 45–48 1987

WINTER FOODS OF AMERICAN COOTS IN THE NORTHERN SAN JOAQUIN VALLEY, CALIFORNIA [1]

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Food contents were identifed from 41 American Coots, *Fulica americana,* collected in November and December on the Los Banos Wildlife Area in California. Esophageal and gizzard contents were analized separately. In the esophageal sample, plant material constituted 90.2% of the food volume and 91.3% of the aggregate percent and was found in all birds; while animal material accounted for 9.8% of the food volume and 8.7% of the aggregate percent and was found in 41.5% of the birds. Insects were the major animal foods with the family Chironomidae the most important. A comparison of this coot data to similar data collected on Northern Pintails, *Anas acuta,* from the same area showed few similarities. In gizzard data, plant material accounted for 99.5% of food volume, while animal material was only 0.5%; suggesting that previous studies of coot food habits based on gizzard contents underestimated the importance of animal foods in their diets.

INTRODUCTION

This report presents a food habits analysis based on gizzard and esophageal contents of 41 American Coots, *Fulica americana,* collected on seasonal wetlands of the Los Banos Wildlife Area (WA), Merced County, California. The objective of this study was to document coot food habits for comparison with similar data being collected on ducks on the Los Banos WA.

Food habits of coots have been infrequently reported in the literature. Eley and Harris (1976) performed an analysis using the combined contents of the gizzard, esophagus and proventriculus, while Munro (1939), Jones (1940), Stollberg (1949), and Thompson (1973) analyzed only gizzard contents. Other data on coot food habits have been reported incidentally by Wetmore (1920), Bent (1926), Harris (1954), Ryder (1961), and Burger (1973). Swanson and Bartonek (1970) demonstrated that analyses of gizzard contents inflate the importance of seeds and deflate the importance of soft-bodied invertebrates in the diets of waterfowl.

METHODS

Coots were collected between 25 November and 30 December 1977 on seasonally flooded ponds of the Los Banos WA. Birds were observed feeding for at least 15 min to insure the presence of food items in their esophagi, then were shot. Gizzards with esophagi attached were immediately removed and placed in a 10% formalin solution for preservation. Sex, date collected, location, surrounding vegetation, and water depth were recorded for each specimen. Sex was determined by examination of reproductive organs. No attempt was made to age the birds. Food items from esophagi and gizzards were identified and after being air dried, volumes were determined by water displacement in a graduated cylinder. Esophageal data were summarized as aggregate volume

[1] Accepted for publication March 1986.

(Martin, Gensch, and Brown 1946), aggregate percent (Swanson et al. 1974), and frequency of occurrence. Gizzard data were summarized as aggregate volume for comparison with previous studies. Volumes were recorded to the nearest 0.1 ml. Items measuring less than 0.5 ml were recorded as trace items and used in the frequency of occurrence tabulation.

RESULTS AND DISCUSSION

In the esphageal analysis, plant material constitutes 90.2% of the food volume and 91.3% of the aggregate percent of the sample and was found in all birds (Table 1). Filamentous green algae, *Pithophora* sp., accounted for the highest percentage of food volume in the sample, although vegetative vascular plant parts totaled a higher percentage of food. Plant seeds were not as important in terms of volume of food comsumed although seed volume was higher than animal volume in the sample. Animal material accounted for 9.8% of the aggegrate volume, 8.7% of the aggregate percent, and was found in 41.5% of the birds. Insects associated with aquatic environments were the major animal foods, with Chironomidae the most important.

Connelly and Chesmore (1980) reported on foods of Northern Pintails, *Anas acuta,* collected on the Los Banos WA during 1976 and 1977. Their data shows that total plant material consumed by pintails during November and December averaged 30% of aggregate volume, while animal material averaged 70%. Similar to my data, the most important animal food in pintail diets was chironomids. Major differences in esophageal contents of coots compared to pintails in these two studies include: (i) pintails consumed no algae, while algae comprised 28.5% of the aggregate of coot diets, (ii) pintail diets contained 30% plant material (primarily seeds), while coots diets contained 90.2% plant material (primarily vegetative plant parts and algae), and (iii) pintail diets contained 70% animal material, while coot diets contained 9.8%. Based on this comparison, it appears that diets of coots and pintails were quite different and it is unlikely that serious competition for food existed between these two species during this period at Los Banos WA. Of the 41 coots collected, 20 were males and 21 were females. I compared aggregate percent of vegetative vascular plant parts, seeds, algae, and animal contents in the esophagi of each sex. Males consumed more vegetative vascular plant parts than females ($z=2.0769$, $P<.05$), while females consumed more animal material than males ($z=-2.3283$, $P<.05$).

In the gizzard analysis, plant material constituted 99.5% of the aggregate volume, while animal material constituted only 0.5%. My gizzard data and previous research by Munro (1939), Jones (1940), Stollberg (1949), and Eley and Harris (1976) on coot food habits during winter months (based primarily on gizzard analysis) resulted in reported percent animal material ranging from 0 to 1.2% of aggregate volumes. My esphageal contents analysis resulted in animal material comprising 9.8% of aggregate volume. This supports the findings of Swanson and Bartonek (1970) that gizzard analyses tend to deflate the importance of soft-bodied animal material not only in waterfowl diets, but American Coots as well. It also suggests that previous food habit studies which were based upon gizzard contents underestimated the importance of animal foods in the diets of coots.

TABLE 1. Esophageal Contents of 41 American Coots Collected 25 November Through 30 December 1977 in Seasonally Flooded Wetlands on the Los Banos Wildlife Area, Merced County, California

Food items	*Percent Aggregate Volume*	*Aggregate Percent*	*Percent Occurrence*
Plant			
Algae:			
Pithophora sp.	28.5	29.7	56.1
Vegetative vascular plant parts:			
Paspalum distichum	26.7	20.3	29.3
Scirpus maritimus	13.5	9.8	19.5
Echinochloa crusgalli	5.5	6.9	12.1
Distichlis spicata	1.3	1.3	4.9
Unidentified fragments	1.1	1.2	2.4
Heleochloa shoenoides	0.2	0.7	4.9
Plant seeds:			
Heleochloa shoenoides	4.2	7.4	4.9
Echinochloa crusgalli	2.8	4.6	10.0
Rumex crispus	2.0	6.5	10.0
Scirpus spp.	1.3	1.0	12.2
Paspalum distichum	1.3	1.1	7.3
Trifolium sp.	0.8	0.3	4.9
Aster alexis	0.6	0.1	4.9
Juncus sp.	0.4	0.4	4.9
Total Plant:	90.2	91.3	100.0
Animal			
Insecta:			
Chironomidae	5.5	5.3	26.9
Ephydridae	1.1	0.4	4.9
Ciccadellidae	0.6	0.6	4.9
Corixidae	0.5	0.6	4.9
Dytiscidae	0.4	0.3	4.9
Insect fragments	0.5	0.6	4.9
Gastrapoda:			
Lymaneidae	0.6	0.5	4.9
Ostracoda:			
Ostracods	0.6	0.4	10.0
Total Animal:	9.8	8.7	41.5

ACKNOWLEDGMENTS

My thanks to C. D. Littlefield, M. Miller, J. Beam, and S. Harris for reviewing an earlier draft of this paper, and to N. Euliss for review and assistance with statistics. Special thanks to J. Cawthon for suggesting the study and to A. Cleveland for allowing me time from my other duties to collect the data.

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NOTES

TWO SPECIES OF KYPHOSIDAE SEEN IN KING HARBOR, REDONDO BEACH, CALIFORNIA

On 29 October 1985 three bluestripped chub, *Sectator ocyurus,* and eight to 12 blue-bronze chub, *Kyphosus analogus,* were observed by SCUBA divers near the terminus of the breakwater in King Harbor, Redondo Beach, California (ca. lat 33° 51′ N, long 118° 24′ W). Five subsequent sightings between 29 October and 14 November 1985 suggest that these fishes may have been seeking refuge or become trapped in the thermally-enriched waters (Stephens and Zerba 1981) surrounding the Redondo Beach Steam Electric Generating Station. Vertical temperature profiles taken on each of the six days show that a sizeable gradient (24.0–15.7°C) did exist within the harbor (John Stephens, Occidental College, unpubl. data). *Sectator ocyurus* (Figure 1) were always observed in the water column and in loose association with a large school of sargo, *Anisotremus davidsonii.* Two *Sectator* were often seen swimming together, but it is not known if the individual make-up of the pair remained constant throughout each of the sightings. *Kyphosus analogus* swam near the substrate in close association with both *A. davidsonii* and the zebra perch, *Hermosilla azurea.*

FIGURE 1. *Sectator ocyurus* swimming in King Harbor, Redondo Beach, California. Photograph by Michael M. Singer, October 1985.

Sectator ocyurus and *K. analogus* are tropical members of the family Kyphosidae and are known as far south as Ecuador (Lindquist 1978). The presence of *S. ocyurus* in King Harbor represents a northern extension of approximately 68 nautical miles, with the previous northern limit, Encina Power Plant, Oceanside, California, (Robins et al. 1980) constituting the only other California record. Though the *K. analogus* seen in King Harbor do not constitute an extension of the range for this species, their occurrence in an aggregate of eight to 12 individu-

als does warrant note. Prior to their sighting in King Harbor, only three specimens had been observed in California: two taken separately near the Encinca Power Plant, Oceanside, in 1972 (Crooke 1973) and a third taken from Monterey Bay in 1974 (Robert N. Lea, Calif. Dept. of Fish and Game, pers. comm.). Tropical species are not uncommon in the temperate waters of southern California, especially during periods of anomolously warm water associated with El Niño Southern Oscillation (ENSO) events. Radovich (1961) presents a detailed review on several such incursions by southern species into California waters. The presence of *S. ocyurus* and *K. analogus* in King Harbor may represent individuals which migrated northward during the ENSO event of 1982–1984. With the return of colder water to the California coast following the lastest El Niño, these fishes may have become attracted to the artificially warmed water surrounding the Redondo Beach plant.

ACKNOWLEDGMENTS

Several people deserve mention for their help; most notably John S. Stephens, Jr., Milton S. Love, Michael M. Singer, and Pamela A. Morris. I would also like to thank Richard H. Rosenblatt for his assistance in identifying *S. ocyurus* and Robert N. Lea for his help in establishing the current range limits for both species.

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OCCURRENCE OF THE FAMILY NOTACANTHIDAE (PISCES) FROM MARINE WATERS OF CALIFORNIA

Notacanth fishes comprise a primarily deep-shelf and upper slope group which is distributed throughout the world oceans. The family Notacanthidae, order Notacanthiformes, is commonly referred to as spiny eels. In the eastern North Pacific, excluding the Bering Sea, two species are known: *Polyacanthonotus challengeri* Vaillant and *Notacanthus chemnitzii* Bloch.

McDowell (1973), in reviewing the Notacanthidae, discussed infrafamilial relationships and provided a key to known species. Peden (1968) reported on the first notacanths taken in the eastern North Pacific; these were two specimens of *Macdonaldia challengeri* (=*Polyacanthonotus challengeri*) from off British Columbia (lat 50° 54.5′N, long 130°06′W, 2105–2196 m). Stein and Butler (1971) provided an additional record of *P. challengeri* from 120 km off Cape Falcon, Oregon (lat 45° 39.4′N, long 125° 57.3′W, 2450 m). Peden (1976) next documented a second species, *Notacanthus chemnitzii* from the eastern North Pacific. Four specimens (two collections) apply to this record, all from off Oregon (lat 45° 50′N, long 125° 06′W and lat 45° 54′N, long 125° 05′W, with corresponding depths of 1536 and 1554 m).

On 7 November 1984 the research vessel CAYUSE, fishing a 40-ft. otter trawl, captured a spiny eel of 319 mm standard length (SL), identified by us as *Notacanthus chemnitzii,* off Pt. Sur, California (lat 36° 26.4′N, long 122° 14.0′W, 1200 m) (Figure 1, Table 1). On 23 March 1986, the trawler NEW MISS ENEZ captured another *N. chemnitzii,* 563 mm SL, from the edge of Monterey Submarine Canyon (lat 36° 41.3′N, long 122° 10.9′W) at ca. 1100 m. This specimen (Table 1), was taken along with Dover sole, *Microstomus pacificus* (the target of the tow), and other miscellaneous fishes including a blob sculpin, *Psychrolutes phrictus* (513 mm SL, 7175g). The above two captures constitute the first records of the family Notacanthidae from Californian waters. *Notacanthus chemnitzii* is a benthopelagic species of worldwide distribution, with the exception of tropical latitudes (McDowell 1973).

The Pt. Sur specimen is deposited in the Collection of Marine Vertebrates, Scripps Institution of Oceanography, SIO 85-52, while the Monterey Submarine Canyon specimen is accessioned in the Department of Ichthyology, California Academy of Sciences, CAS 58441.

ACKNOWLEDGMENTS

We would especially like to thank Dale Rappe and the crew of the NEW MISS ENEZ, who on a number of occasions have saved unusual organisms in the interest of science. Alex E. Peden, British Columbia Provincial Museum, provided information on eastern Pacific notacanth fishes. M. Eric Anderson, California Academy of Sciences, took radiographs and commented on notacanth systematics.

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FIGURE 1. Illustration of *Notacanthus chemnitzii*. Reproduction of plate from original description by Marcus Elieser Bloch dating from 1787. Courtesy of Library of Congress.

TABLE 1. Meristic and Morphometric Data for Two California Specimens of *Notacanthus chemnitzii*[1]

	SIO 85-52	*CAS 58441*
Counts:		
Dorsal fin	IX, 2	IX, 2
Anal fin	XVII, 115	XVII, 127
Vertebrae	54+180	54+171
Pectoral fin	15-16	15-15
Pelvic fin	IV, 6-7, IV	IV, 6-6, IV
Caudal rays	3+2	3+2
Branchiostegals	10	10
Dorsal fin position:		
Origin-vert. no.	41	47
Insertion-vert. no.	68	73
Origin of anal fin	under D5	between D4-5
Measurements:		
Standard length	319	563
Total length	329	575
Gnathoproctal l.	139.7	233.3
Predorsal l.	127.2	227.5
Preanal l.	150.0	256.4
Head l.	55.2	98.1
Eye dia. (=spectacle)	10.2	15.5
Snout l.	11.8	22.0
Eye (post.) to edge of opercle	35.6	63.6
Snout to ant. border of mouth	12.1	21.8
Interorbital width (fleshy)	12.2	17.4
Length of upper jaw	14.4	38.4
Pectoral fin l.	28.5	44.2
Pelvic fin l.	20.5	30.9
Body depth at:		
1) Pectoral fin base	36.6	65.3
2) Pelvic fin base	41.9	71.2
3) Origin of anal fin	39.4	66.4
4) Posterior part of orbit	29.4	47.4
Body width	15.0	34.0
Pelvic origin to anal origin	28.8	47.4
Gill raker l.	2.8	6.7
Gill filament l.	7.1	10.0
Weight (g.)	–	525

[1] First dorsal spine buried; last two dorsal elements soft-rays. First two anal spines buried in larger specimen; not buried in SIO specimen. Seventeenth anal element intermediate between a spine and a soft-ray. Branchiostegal rays either 9 or 10, depending on whether posteriormost is counted (see McDowell 1973, p. 194). Vertebrae, of SIO 85-52, under posterior part of dorsal fin abnormal, crowded, apparently diplospondylus.

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—Robert N. Lea, Marine Resources Division, California Department of Fish and Game, 2201 Garden Rd., Monterey, California 93940 and Richard H. Rosenblatt, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California 92093. *Accepted for publication July 1986.*

RANGE EXTENSIONS OF OFFSHORE DECAPOD CRUSTACEANS FROM CALIFORNIA AND WESTERN MEXICO

Ranges of decapod crustaceans from the lower continental shelf and slope are poorly studied. While compiling information on distributions of offshore species of the eastern Pacific, I examined specimens in the collections of research institutions in California. Among their holdings, I found range extensions of eight species. These records are presented here as given by the data accompanying the specimens—not all of the material has been catalogued yet, nor do all of the specimens bear the names of the vessels that took them or their exact dates or locations of collection. I thank Janet Haig, Allan Hancock Foundation (AHF), University of Southern California; Dustin Chivers, California Academy of Sciences (CAS); and Spencer Luke, Scripps Institution of Oceanography (SIO) for enabling me to examine material in their respective collections.

ORDER DECAPODA

INFRAORDER CARIDEA:

Family Hippolytidae

Spirontocaris sica Rathbun

Previous recorded range.—Restoration Bay, Burke Channel, British Columbia, to San Diego, California, 88-849 m (Butler 1980).

New record.—West coast of Baja California, Mexico: 10 specimens, between San Benito Islands and Cedros Island (lat 28° 18'N, long 115° 23'W), 6-foot Sigsbee trawl, 265-247 m, 27 May 1971, AGASSIZ sta. MV71-32, SIO C2546.

Family Pandalidae

Pandalopsis ampla Bate

Previous recorded range.—Washington to Mexico, and off "Monte Video", 553-1986 m (Schmitt 1921).

New record.—Gulf of California, Mexico: 1 specimen, E of Isla Carmen, (lat 25° 53'N, long 110° 41'W), free vehicle trap, 1061 m, 23 Jan 1968, T. WASHINGTON sta. MV68-I-76, SIO C2312.

Remarks.—Takeda and Hatanaka (1984) have suggested that the populations of this shrimp in the southwestern Atlantic and northeastern Pacific may belong to separate species.

INFRAORDER ANOMURA

Family Axiidae

Calocaris quinqueseriatus (Rathbun)

Previous recorded range.—Sea of Okhotsk, Vancouver Island to San Nicolas Island, California, 288-2200 m (Hart 1982).

New records.—Gulf of California, Mexico: 1 specimen, off Isla Ángel de la Guardia (lat 28° 58'N, long 113° 16'W), 1136-1141 m, 1 Dec 1967, VELERO IV sta. 11827, AHF. 1 specimen, off Isla Tortuga (lat 27° 31'N, long 111° 35'W), 1777-1786 m, 27 Nov 1967, VELERO IV sta. 11808, AHF. 1 specimen, lat 27° 31'N, long 111° 34'W, 1768-1777 m, 27 Nov 1967, VELERO IV sta. 11809, AHF. 20 specimens, lat 27° 29'-18'N, long 111° 44'-36'W, 1612-1649 m, 28 Nov 1967, VELERO IV sta. 11815, AHF.

Family Callianassidae

Callianassa goniophthalma (Rathbun)

Previous recorded range.—Clarence Strait, Alaska to off Harris Point, San Miguel Island, California, 483-651 m (Hart 1982).

New records.—California: 1 specimen, 4.9 mi. off Pt. Dume (lat 33° 57′-58′N, long 118° 53′W), 485-632 m, 18 Dec 1975, VELERO IV sta. 24031, AHF. 1 specimen, 10.4 mi. off Pt. Vicente (lat 33° 42′N, long 118° 36′-35′W), 550-623 m, 9 March 1976, VELERO IV sta. 24480, AHF. 1 specimen, 1.5 mi. off White Pt. (lat 33° 43′-42′N, long 118° 20′W), 20 -27 m, 11 March 1976, VELERO IV sta. 24511, AHF.

Family Galatheidae

Galathea californiensis Benedict

Previous recorded range.—Monterey Bay, California to off "Cerros" Island, Baja California, Mexico, 105-4028 m (Schmitt 1921).

New records.—California: 1 specimen, off Santa Cruz (lat 36° 55′N, long 122° 0′W), rocky bottom, (no date), CAS.—Gulf of California, Mexico: 1 female, off Isla San Pedro Nolasco (lat 27° 58′-59′N, long 111° 23′-24′W), 101-104 m, rocky bottom, 6 Feb 1940, VELERO III sta. 1085-40, AHF.

Munida hispida Benedict

Previous recorded range.—Off Santa Catalina Island, California to off the Galapagos Islands, 292-500 m (Schmitt 1921).

New records.—California: 1 specimen, Monterey Bay (ca. lat 36° 50′N, long 121° 50′W), 185 m, March 1971, CAS. Also 26 specimens from off Santa Cruz Island and Anacapa Islands, California, AHF.

Family Lithodidae

Paralithodes rathbuni (Benedict)

Previous recorded range.—San Simeon Bay, California to San Diego, 368-403 m (Schmitt 1921).

New records.—West coast of Baja California, Mexico: 1 specimen, small juvenile, 5 mi. S of San Benito Islands, (lat 28° 12′-13′N, long 115° 33′-34′W), 159-174 m, sand, 19 Feb 1940, VELERO III sta. 1119-40, AHF. California: 1 specimen, between Pt. Lobos and Soberanes Pt., Monterey County (ca. lat 36° 30′N, long 122° 05′W), JACKIE BOY, 4 March 1972, CAS. 1 specimen, off Pigeon Pt., San Mateo County (lat 37° 15′N, long 122° 25′W), 201 m, 2 Aug 1932, CAS. 1 specimen, off Pigeon Pt., (no date or depth), CAS. 1 specimen, Cordell Bank (lat 38° 0′N, long 123° 30′W), 92-137 m, 26 March 1949, AHF.

Family Parapaguridae

Parapagurus haigae de Saint Laurent

Previous recorded range.—Gulf of California, Gulf of Panama, 55-250 m (de Saint Laurent 1972).

New records.—Off San Miguel Island, California: 1 specimen, (lat 33° 57′N, long 120° 25′-27′W), 220-224 m, 24 April 1976, VELERO IV sta. 24815. 1 specimen, (lat 33° 58′-59′N, long 120° 27′-28′W), 185 m, 28 July 1977, VELERO IV sta. 26308. Also over 150 specimens from 36 stations: Santa Rosa, Santa Cruz, Anacapa, Santa Barbara, Santa Catalina, and San Clemente Islands, Tanner and

Cortez Banks, off Hueneme and San Pedro Channel, California, and San Jaime Bank off Cabo San Lucas, Mexico (lat 22° 51'N, long 110° 15'W), AHF.

Remarks.—In the original description, the type locality of *P. haigae* was given as "Allan Hancock Foundation Station 99-339, golfe de Californie". The station number and location were incorrect. Station 993-39, from which the holotype came, is off Santa Cruz Island, California (lat 33° 56'N, long 119° 43'N). The species does, however, range into the Gulf of California, Mexico. There are over 40 specimens from seven stations from the Gulf of California among the collections of the Allan Hancock Foundation.

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—Mary K. Wicksten, Department of Biology, Texas A&M University, College Station, TX 77843. *Accepted for publication May 1986.*

RECORD OF THE TWINPORED EEL, *XENOMYSTAX ATRARIUS* (ANGUILLIFORMES: CONGRIDAE) FROM CALIFORNIA WATERS

An adult twinpored eel, *Xenomystax atrarius* Gilbert, 1891, was caught on 18 December 1985 by a dory fisherman off Newport Beach, Orange County, California (Figure 1). The eel was caught on a set line baited with salted anchovy in approximately 500 m of water and is deposited in the Natural History museum of Los Angeles County (LACM 44131-1). The specimen agrees well with the redescription of *X. atrarius* by Peden (1972), represents the first reported adult of *X. atrarius* from California waters, and may be the first known California specimen.

The data for this specimen are: 610 mm total length; male, running ripe ". . . specimen secreted milt . . ." (D. J. Long, pers. comm.). Color after preservation in 90% denatured alcohol and storage in 70% ethanol: nearly uniformly jet black dorsally to dark brown laterally; pores prominent and ringed in white; eyes and nares outlined in white tissue; small gray-white patch of skin dorsally between eyes and nares; fins black except distal half of pectoral fins white (translucent); oral membranes mostly white, dotted with small black melanophores between anterior premaxillary teeth; membranes surrounding vomerine and palatine teeth white, dotted with small black melanophores posterior to vomerine tooth patch; membrane between mandibles dotted with small black melanophores. Stomach empty; however, remains of a juvenile Pacific hake, *Merluccius productus,* were found in pharynx. Counts are given in Table 1. Otolith (right sagitta, Figure 2) with short, concave dorsal margin; ventral margin convex with slight denticulation; posterior margin broadly rounded; rostrum protuberant; sulcus moderately long, ostial colliculum about one-half length of caudal colliculum.

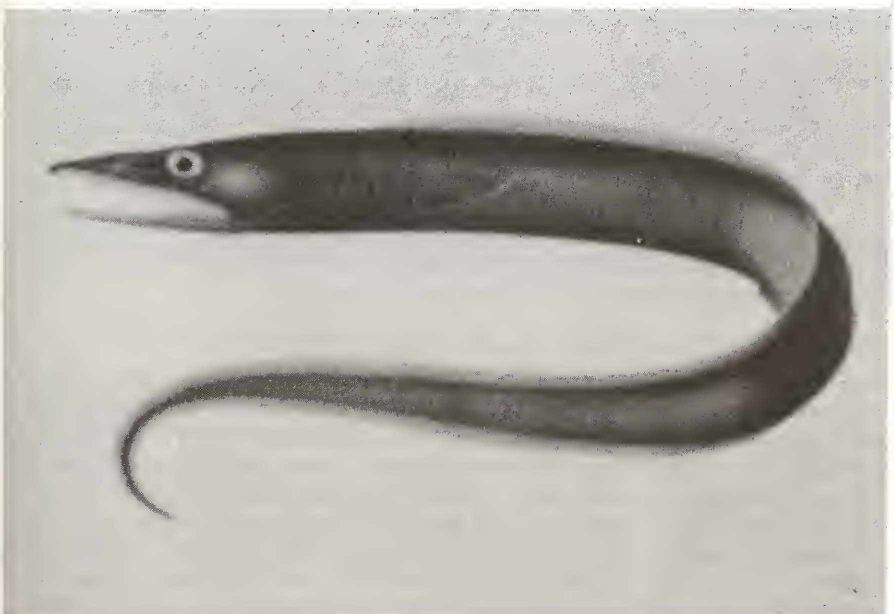

FIGURE 1. Lateral view of *Xenomystax atrarius,* reproduced from Garman (1899).

TABLE 1. Counts for *Xenomystax atrarius,* LACM 44131-1, 610 mm TL, male, following Peden (1972). Tooth counts include sockets

Caudal fin rays	8
Pectoral fin rays (right fin)	11
Lateral line pores ant. to anus	39
Lateral line pores ant. to pectoral fin base	8
Precaudal vertebrae	48
Caudal vertebrae	123
Branchiostegal rays	11
Premaxillary teeth	34
Large median teeth on vomer	7
Small median teeth on vomer	no count
Small lateral teeth on vomer:	
left (damaged)	7
right	11

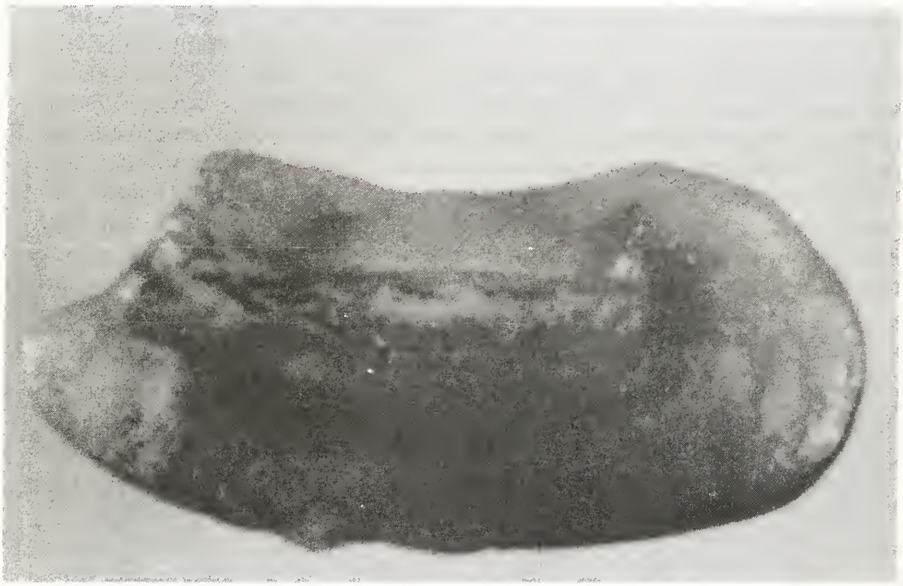

FIGURE 2. Right sagitta of *Xenomystax atrarius,* LACM 44131-1.

A reported California record of *X. atrarius* (Fitch and Lavenberg 1968, Peden 1972,) was based on an equivocal leptocephalus (LACM 6901-16) from the San Clemente Basin. Peden (1972 stated that "When the specimen (195 mm standard length) is . . . examined with a binocular microscope, 15 branchiostegal rays can be observed through the transparent skin. Because only 11 or 12 rays were observed in the *X. atrarius* in this study, this leptocephalus is not likely to be *X. atrarius*. However, its identity is still unknown." This specimen is presently missing from the LACM collections and its identity is still in question. Thus, the *X. atrarius* reported in this paper may be the first record of the species from California.

Xenomystax atrarius inhabits eastern Pacific continental slope waters from Vancouver Island, British Columbia, Canada, to Valparaiso, Chile, including one record near the Galapagos Islands, and specimens from low latitudes were taken at greater depths (588–935 m) than those from higher latitudes (165–457 m) (Peden 1972). The present specimen was captured at a temperate latitude (ca. lat 34° N, 500 m) in deeper water than the specimen from off Vancouver Island, British Columbia (ca. lat 48° N, 446–457 m) and the three Chilean specimens (ca. lat 27–33° S, 165 and 400 m) (Peden 1972).

Xenomystax has been placed variously in three anguillifrom families: Congridae, Muraenesocidae, and Nettastomidae. Smith (1984) reviewed the relationships of the anguilliform fishes, noting that *Xenomystax* probably belongs within the Congridae.

ACKNOWLEDGMENTS

I thank D. J. Long for donation of the specimen, R. J. Lavenberg for identification of hake otoliths, T. Iwamoto, and H. J. Walker for their help and information, C. C. Coney for the use of his microscope and camera, and R. J. Lavenberg, C. C. Swift, and D. M. Cohen for review of the manuscript.

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RESIGHTINGS OF TWO REHABILITATED AND RELEASED HARBOR SEALS IN CALIFORNIA

In this note we document the resighting of two previously stranded, rehabilitated, and subsequently released harbor seals, *Phoca vitulina richardsi.* Both juvenile seals moved north, away from their release areas. When resighted, they appeared healthy and one was hauled out among other harbor seals.

Infant and juvenile harbor seals are regularly found stranded on beaches in California during the spring pupping season and summer months. Participants in marine mammal stranding networks contact rehabilitation facilities such as the California Marine Mammal Center (CMMC) when they discover harbor seals that are orphaned, sick, or injured. While undergoing treatment, human contact with animals is minimized, and seals of similar age classes are housed together to encourage seal "socialization." Rehabilitated seals are released near known harbor seal haul out sites. Prior to release, seals are tagged in the webbing of rear flippers with green Dalton-Riese "all-flex" tags and are dye-marked with Lady Clairol "Ultra-Blue" hair dye for easy identification in the field.

From 1975 to 1982, CMMC recovered and treated 135 beached harbor seals. Of these, one was kept in captivity at an aquarium and 31 (23%) were released. Of the 31 released, 27 (87%) were tagged, and all were young of the year. By the end of 1982, two of the tagged seals, representing 7% of the seals released, were resighted. The following is an account of resightings and captive histories of these seals.

CMMC recovered an infant seal, HS95, from Ano Nuevo State Reserve on 16 June 1981. HS95 weighed 13.3 kg, was estimated to be about one month old, and was a female. Although aggressive and not particularly emaciated, HS95 was weak and slow to respond when approached or handled. She had eight regularly spaced lacerations, each up to 5 cm in length on her left side, that were patterned in an arc running from just dorsal and posterior to her left axilla, to slightly anterior to the insertion point of her left rear flipper. All lacerations penetrated the skin and fascia and entered the muscle, but none continued through into the underlying body cavity. Collectively, the lacerations formed an arc measuring 34.3 cm long and 6.4 cm high at the central apex. Although there were no corresponding punctures on the seals' dorsal surface, this injury may have been the result of a shark bite.The lacerations were cleaned and medicated, and they healed rapidly. Fecal examinations for parasites were negative. HS95 was initially fed a fish-based formula by stomach tube, and was then weaned onto a diet of whole herring, *Clupea harengus.* At the time of her release HS95 weighed 26 kg. HS95 was tagged with number "L2" in the webbing of her left rear flipper, and the letters "JEN" were bleached into the fur on her dorsal surface posterior to her head. HS95 was released at Pebble Beach Bean Hollow State Park, San Mateo Co., California (lat 37° 12'N, long 122° 24'W) on 31 January 1982.

HS95 was resighted three times in 1982 on a beach at Point Reyes Headland, California (lat 37° 59'N, long 122° 59'W), during routine harbor seal censuses by C. Poulsen of the Point Reyes Bird Observatory. Point Reyes Headland is 80 km north of the release site. The large tag, seen at 100 m with 9 x 35 binoculars, made resightings of HS95 easy. The dye stain had faded so that after 93 days it was visible, but the letters were unrecognizable. On 4 May, HS95 was hauled out with 63 harbor seals including 29 juveniles; on 13 May, she was part of a group

of 15 seals including three juveniles; and on 3 June, she was hauled out with 23 seals including 11 juveniles. HS95 appeared healthy and uninjured, and similar in weight, size, and behavior to other harbor seals of her age class. Semi-monthly censuses were carried out at several harbor seal haul out sites in Point Reyes through March 1984, but HS95 was not resighted.

A seal pup, HS111, was recovered by CMMC from Whales Head Cove Beach, Oregon, on 24 April 1982. The female seal was estimated to be less than one week old based on aging criteria in a report by Boulva and McLaren (1979), and weighed 8.3 kg. HS111 was placed on a herring-based formula administered by stomach tube, and after 12 days was weaned onto a diet of whole herring and smelt, *Thaleichthys pacificus*. She demonstrated no clinical problems and gained weight rapidly. Prior to release HS111 was tagged number "L35" in the webbing of her left rear flipper. She was released on 24 October 1982 with five other juvenile harbor seals of similar age including four females and one male at Point Reyes Headland, California. By the time of her release she weighed 32.2 kg. She was resighted 14 days later on 7 November by J. Mazzeo (of CMMC) hauled out on a skiff anchored offshore in Bodega Bay, California (lat 38° 17', long 123° 03'W), a distance of 42 km from her release site. At the time of resighting she appeared healthy and uninjured. She has not been sighted again.

Both seals traveled north from their release sites before being resighted. HS95 was first resighted 93 days after release, and last sighted 34 days later yielding a minimum post-release survival of 127 days. HS111 was resighted only once 14 days after release.

The travels of non-rehabilitated, tagged harbor seals have been documented in other studies (Brown and Mate 1983, Hanan 1985, Pitcher 1979) and the distances traveled have been greater than recorded for these rehabilitated individuals. Nevertheless, this is the first documentation of the northward movement of a harbor seal in this locale to an established harbor seal haul out site. The findings of Harvey, Brown, and Mate (1983) combined with those reported here demonstrate the survival, in apparent good condition, of four rehabilitated harbor seals 14 to 127 days post release. More studies of this kind are needed to determine the movements of and the survival rates of rehabilitated pinnipeds, and to discern what process of adjustment, if any, the animals experience.

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BOOK REVIEWS

A Field Guide To Western Reptiles and Amphibians (Second Edition, Revised).

By Robert C. Stebbins. Houghton Mifflin Co., Boston, 1985; xiv+336 p. $17.95 cloth, $12.95 paper.

Robert Cyril Stebbins' long awaited, second edition of *A Field Guide To Western Reptiles and Amphibians* once again reaffirms his position as a premier field guide author and scientific illustrator. Completely revised and expanded to include the Baja California herpetofauna, this book represents the most up-to-date catalogue of salamanders, toads, frogs, turtles, lizards, and snakes inhabiting the western United States and Canada.

As with the previous 1966 edition, the guide is designed to allow quick, easy, and accurate identifications in the field. Beautifully detailed illustrations (most of which are in color) are grouped together in the middle of the text to facilitate rapid identification of the organism in question. There is also a simple identification key in Chapter 5 (with appropriate line drawings) that serves as a short cut to the correct illustration or group of illustrations. Newly revised distribution maps for each species and subspecies are grouped together at the end of the text.

The author begins the book with a useful introduction on how to use the guide, a general overview of the differences between sexes in major groups of amphibians and reptiles, voice characterizations, breeding habits, distribution, and his justifications for the inclusion (and exclusion) of various subspecies and choice of common names. Additional chapters deal with making captures, caring for captives, field study, and protection. The bulk of the text is devoted to useful discussions of the description, habits, habitat, range, and ecology of each species. Many of these discussions incorporate recently published material and clarify the status of threatened and endangered sepcies. The final portion of the guide includes a key to amphibian eggs and larvae, a useful glossary, list of references, and an index.

I noted few errors and omissions in this work. The species names for *Bufo woodhousii* and *Coleonyx* [=*Anarbylus*] *switaki* are misspelled throughout the text and the distribution of *Masticophis lateralis euryxanthus* on map 132 is incorrectly plotted (see Jennings 1983a). Additionally, I noted that the State of California was inadvertently omitted from the listing of "Regional References" on page 279. Suitable publications for California would include Stebbins (1972) and Jennings (1983b).

However, these minor oversights in no way detract from the usefulness of this book. Both amateur and professional herpetologists, as well as resource managers, will find this a useful compendium of information and an indication of changes in the field of herpetology over the past 20 years. The price of $12.95 paper and $17.95 cloth make this field guide a real bargain (considering the excellent plates and quality of paper) and I highly recommend this book for anyone even remotely interested in the herpetofauna of western North America.

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—*Mark R. Jennings*

Between Pacific Tides, Fifth Edition

Ricketts, Calvin, and Hedgpeth, revised by David W. Phillips. Stanford University Press, Stanford, California, 1986; $29.50

Attempting to review the Fifth edition of any book is certainly treading dangerous ground or, in this case, *Ralfsia*-covered rocks. This is perhaps even more true when the review is of a volume such as the latest morph of "Between Pacific Tides." A large portion of the readership of *California Fish and Game* has undoubtedly read some edition of this time-tested work and perhaps any review would cause the raising of any number of jaundiced eyes. However, something must be said since that is the way of it.

Perhaps the best approach would be to quote David W. Phillips who produced this latest, and very fine, revision. He states in his preface, "The Fifth Edition of Between Pacific Tides is still Ed Rickett's book. Its fundamental purpose and philosophy are those of the original, and it remains a book for all who find the shore a place of excitement, wonder, and want to know more." This may be true, but there is no question that the book has evolved immeasurably. To this reader, the Fifth edition is as far removed from the Fourth as that work was from the First. In his preface, Phillips credits the major impact of Joel Hedgpeth's revisions to the original work. It appears to this reader that Phillips changes have been equally significant, and equally well done.

It would be redundant here to list all the modifications in this edition since these are so well described in the preface. Suffice it to say that no harm was done, the previous editions are still available, and a great deal of new material has been added.

My opening comments regarding the wisdom of reviewing fifth editions can be applied to those attempting to write such revisions. In this case, I believe the work continues a fine tradition. I can hardly wait for the sequel.

—John Grant

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